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Research Highlights 1979

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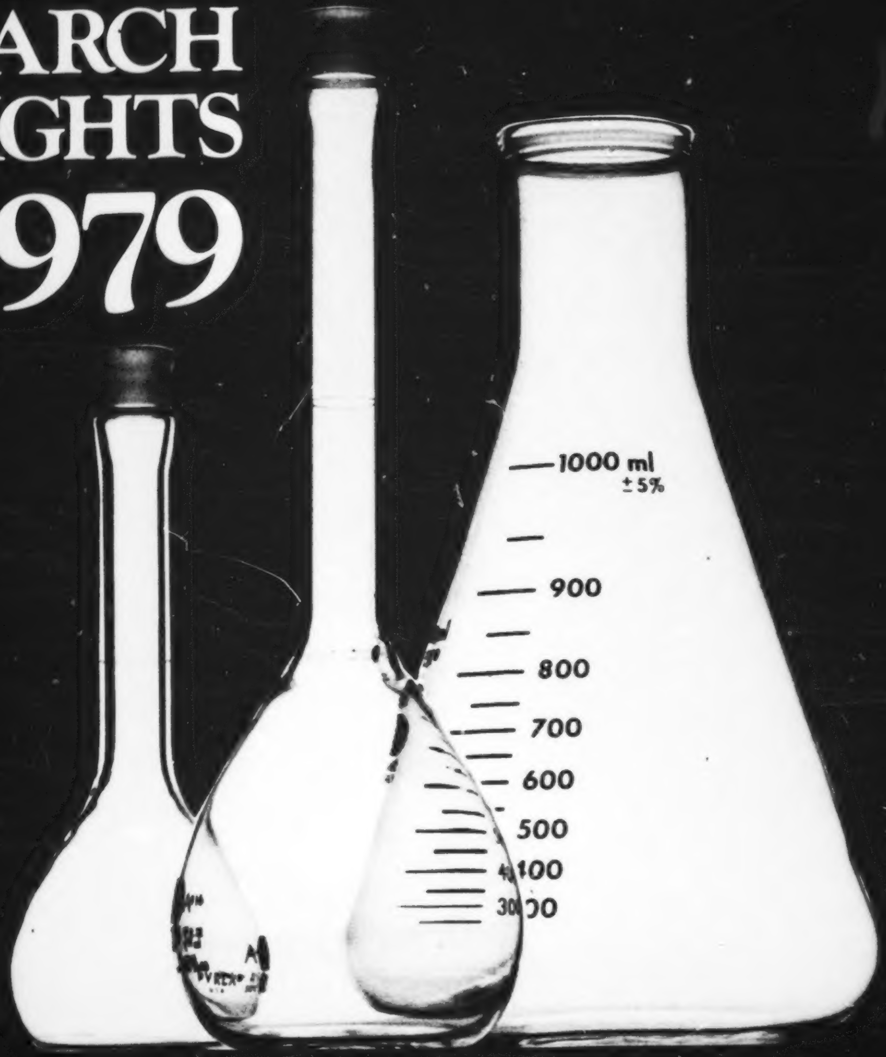
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FOREWORD

Sometimes a piece of accurate information can be a very valuable commodity. In our technologically sophisticated society, the health and welfare of many, if not all, of our citizens are dependent on good scientific data. Such data directly affect our daily lives.

Take the incident at Three-Mile Island, for example. There were millions of people living near the faulty nuclear reactor who didn't know if they should evacuate, if their children were safe outdoors or if they could drink local milk or water. How much was it worth to these people to know for a fact that their lives had not been endangered?

Or, take the hundreds of people who live along the 200-miles of roadway in North Carolina along which highly toxic chemicals (PCB's) had been dumped. Some were afraid they'd already been seriously poisoned and that their property would become worthless — unmarketable. How much was it worth to these people to know that their exposure was not severe and that the spill could be safely removed?

Or what about the nearly 200 people in Oregon who came down with acute gastrointestinal illness — how much is it worth to them to know what caused that illness and that the situation had been corrected?

In every one of the above cases, the answer is obvious—for people's health, safety and financial security the information they wanted was very valuable. And, in each of the above cases, EPA's research program was key to providing the answers.

On an even larger scale, information can be worth (or lack of information can cost) billions of dollars. This is especially true in a regulatory agency such as EPA. We are mandated by law to protect the public health and welfare from unacceptable damage due to polluted air, water or land. To carry out that mandate, EPA establishes regulations which can cost billions of dollars for compliance. EPA's research program helps to ensure that standards are set only as stringently as necessary and that effective measurement and control technologies are available.

For example, in the Toxics chapter is the description of a set of relatively inexpensive test methods developed by ORD that will estimate potential human exposure to newly-developed organic chemicals. These tests will help the EPA in meeting its responsibilities under the Toxic Substances Control Act. Another set of tests described in the Toxics chapter is undergoing study to determine ways to estimate whether certain chemicals cause mutations by damaging genetic material. Such tests will help EPA in future efforts to register chemicals for market.

Other efforts during 1979 have developed sophisticated, laser-based monitoring techniques to measure pollution over considerable distances. One device, for example, can analyze the composition of fumes from a smokestack located up to a kilometer away!

In addition to directly supporting EPA's regulatory functions, EPA's research program also investigates longer-term phenomena in an effort to identify — and prepare for — emerging environmental concerns. For example, EPA's role in developing information on the causes and impact of acid rain is central. While this issue is only beginning to be generally acknowledged, EPA has been developing a major research program in this area for the past several years. In this Highlights you'll read of our findings with regard to lakes in Minnesota and Wisconsin and what we've learned about the impact of acid rain on food crops.

The value of information is even clearer in the results of some of EPA's other research projects. One, for example, promises to produce ethyl alcohol — for use in gasohol — for only about two-thirds of the cost of alternative methods. In addition, EPA's method disposes of waste paper in the process.

Other projects described in this Highlights are providing information on cleaner, more efficient ways to burn coal, on improving the efficiency of flue gas scrubbers, on protecting against exposure to airborne asbestos fibers, on detecting and controlling toxic substances, and on protecting and restoring our lakes, coasts and the abundantly productive fisheries of the Chesapeake Bay.

During 1979, EPA's research program invested approximately $320 million in some 2,200 different research projects, and in excess of $1.6 million and over 125 person-years on technical support efforts. In this year's Highlights report we present a very small sampling of these projects, including those which are mentioned above. In fact, fewer than 1 out of every 30 of our projects are described in this report.

We firmly believe that the information produced by our research has benefits far beyond the costs of the research itself. As you read through this, the third of our Research Highlights reports, I think you'll see why.

Stephen J Gage

Stephen J. Gage
Assistant Administrator
Research and Development

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16. ABSTRACT

The results described in this year's Highlights report represent but a few of the outputs supported by the Office of Research and Development in 1979. The Program ranges from direct support to EPA's regulatory functions, such as the developing of short-term tests for evaluating the toxicity of various substances and developing a classification method for hazardous wastes, to the publication of a new series of research documents to aid the public in learning about such research activities. This report covers studies on acid rain, the Chesapeake Bay, Energy (synthetic and conventional), radiation, clean air monitoring as well as municipal and industrial waste water.

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CONTENTS

Three Mile Island 2
Emergencies/Assistance 5
Energy 14
Acid Rain 26
Clean Air Monitoring 30
Non-Ionizing Radiation 38
Toxics 40
Analytic Techniques 53
Resource Conservation and Recovery Act 57
Water Quality 66
Coastal Environment 72
Chesapeake Bay 77
Wastewater 79
Information Transfer 88
ORD Program Expands 92
ORD Resources 97
The People 99

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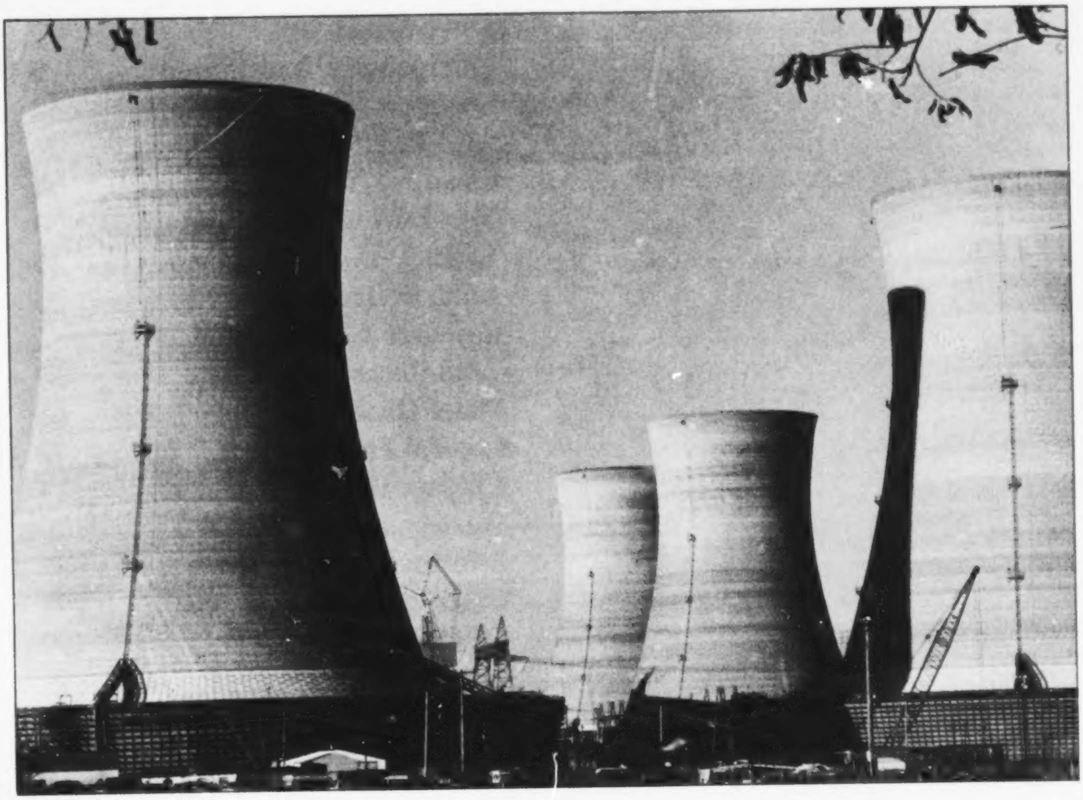
THREE MILE ISLAND



Cooling towers of the Three Mile Island power plant in Pennsylvania

EPA research teams monitor the radiation levels of the country's worst nuclear accident

The Emergency

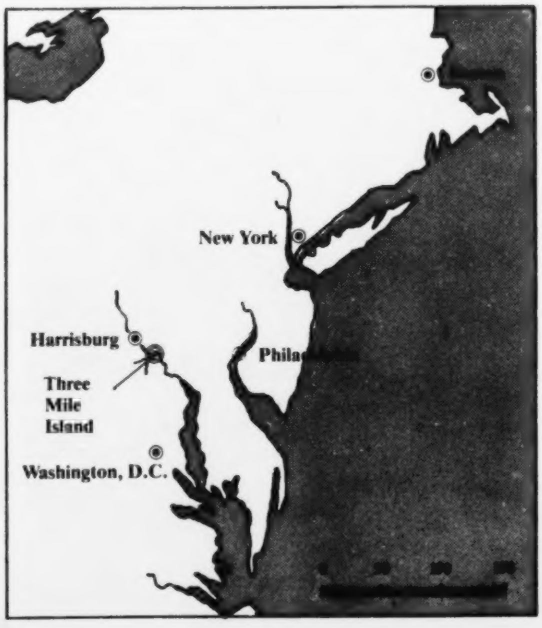
Wednesday, March 28, 1979, at 4 a.m., the nuclear reactor at the Three Mile Island powerplant near Harrisburg/Middletown, Pennsylvania, malfunctioned. Later that morning, government officials were notified of a potential radiation problem, although the seriousness of the malfunction had not yet been recognized. That afternoon, EPA, through its Office of Radiation Programs, began daily sampling of air at three of its Environmental Radiation Ambient Monitoring Systems (ERAMS) stations nearest the reactor.

On Friday, the Nuclear Regulatory Commission (NRC) notified EPA of the serious nature of the malfunction and its potential for creating a core meltdown, which could in turn, result in radiation exposure to people living within a 10- to 15-mile radius of the plant. EPA's Region III Office immediately began taking water samples from the Susquehanna River and Chesapeake Bay. That same day the EPA Administrator, Douglas Costle, asked the Office of Research and Development to assist in an emergency radiation monitoring program around the Three Mile Island plant and to assume leadership of coordinating EPA's overall response to the accident. A monitoring plan was created and approved on the spot.

Within three hours after notification, approximately 10,000 pounds of radiation monitoring and sampling equipment from EPA's laboratory in Las Vegas was loaded onto an aircraft bound for the Three Mile Island area. By early Saturday afternoon, March 31, nineteen ORD radiation scientists and technicians from Las Vegas had arrived in nearby Harrisburg. With them arrived additional monitoring equipment, including a twin Turbo-Beech aircraft equipped for tracking and sampling radioactivity.

EPA made the only actual measurements of radioactive xenon

Immediately following their arrival, the monitoring team began establishing a continuous monitoring and sampling network. Ultimately, this network would consist of 12 stations within a 3-mile radius of the reactor, 10 additional stations within a 6- or 7-mile radius, and 9 more stations at selected populated locations beyond 7 miles from the reactor. By Sunday, April 1, 11 stations were operational. All 31 stations were operating by April 3. Each station was equipped with an air sampler, gamma rate recorder to measure radiation exposure at a given moment, and thermoluminescent dosimeters that measure total radiation exposure. As part of the monitoring effort, EPA made the only actual collections and analyses of radioactive xenon, the principal radioactive material released from the reactor.



To process the samples collected at the monitoring sites and other environmental samples gathered by EPA technicians, the team established an analytical laboratory in nearby Harrisburg. The ORD aircraft performed two sampling missions to collect filtered and compressed air samples and was held on standby for the duration of the critical phase of the emergency for tracking and sampling in the event of a more serious release of radioactivity.

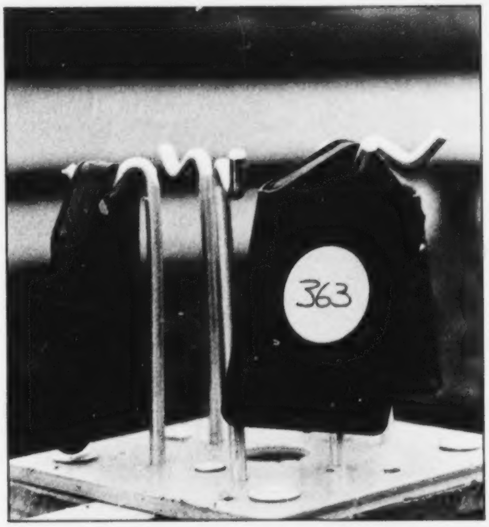
ORD technician at a Three Mile Island monitoring station

Two EPA water sampling stations on the Susquehanna River and three stations on Chesapeake Bay were established, and by Monday, April 2, drinking water samples were collected and tested for contamination. By April 7, all public water supplies within a 20-mile radius of Three Mile Island had been tested. In all, more than 140 water sources were identified, 21 of which were surface water that were more susceptible to radiation, and thus were given sampling priority.

On Wednesday, April 4, daily sampling of effluent discharges from the nuclear reactor were initiated. By late April, a continuous iodine-131 monitor had been developed and installed on the major water discharge from the plant.

ORD aerial photointerpretation techniques were used to identify 570 dairies within 25 miles of the reactor and on April 5, EPA began a daily milk sampling program at nine selected dairy farms. EPA also collected additional air, water, milk, vegetation, soil, and sediment samples for study.

Results of this massive emergency monitoring and sampling effort were encouraging. Only very low radiation levels were recorded for the area—not sufficient, according to an interagency analysis, to produce one additional cancer death in the exposed population. Radioactive iodine in the air was slight, and the radioactive iodine levels found in a few milk samples were so low that the milk was considered safe to drink. There was also no radiological contamination present in water samples, and no radionuclides detected in vegetation, soil, or sediment samples.



Thermoluminescent Dosimeters measure total radiation exposure

As the situation at Three Mile Island stabilized and the threat to public health and safety diminished, the ORD effort was reduced accordingly. By early May, the surveillance program was phased down to 18 continuous monitoring stations, plus the dosimeter network. Other efforts were also reduced and, while the total number of EPA personnel on the scene at the height of the emergency numbered 31, within little more than a month the environmental situation in the area was sufficiently secure to leave the remaining tasks in the hands of five ORD scientists and technicians.

EPA Coordination

Two weeks following the incident at Three Mile Island, EPA was designated by the White House as the lead federal agency for coordinating the follow-up environmental monitoring efforts at the plant site. In this capacity, EPA worked with the NRC and HEW to coordinate monitoring activities and provided the monitoring data for use by DOE. The data from all agencies were pooled and documented to be made available for use by other federal agencies and interested state and local agencies as well. EPA also prepared and delivered a 6-volume compilation of environmental monitoring data to the President's Commission on the Accident at Three Mile Island.

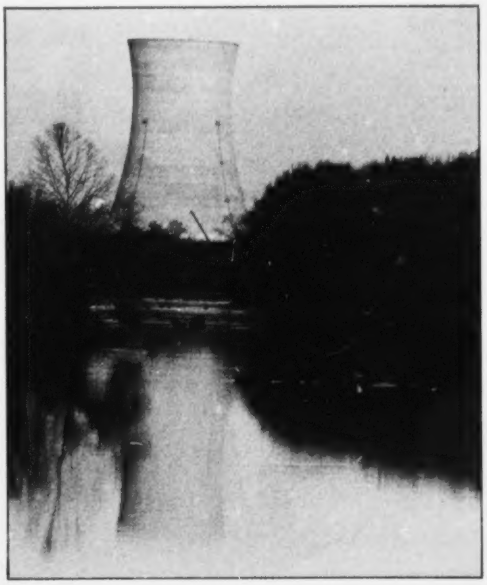
EPA will coordinate a long-term monitoring program

As lead agency, EPA will also coordinate a long-term Three Mile Island radiation monitoring program. This surveillance plan to monitor the cleanup program and other plant activities is expected to be in operation for at least one year, after which time EPA is to submit a report of its monitoring findings.

In the future, it is expected that EPA will play an important role in the formulation of plans outlining even more efficient and effective federal agency response procedures to incidents such as the one that took place at Three Mile Island.

The following ORD components contributed to the research described above:

- EPA Region III, Philadelphia
- Office of Air, Noise and Radiation, Washington, D.C.
- Office of Research and Development, Office of Monitoring and Technical Support—Environmental Monitoring Systems Laboratory, Las Vegas



The Susquehanna River water was sampled by ORD monitoring teams

EMERGENCIES/ASSISTANCE

An ORD team assists in the clean up of a Dittmer, Missouri dump site

Rapid response by ORD helped the analysis and cleanup of health threatening emergencies

During 1979, ORD was called on to respond rapidly to a wide variety of environmental emergencies or to provide technical support in cases of environmental crises. Activities ranged from the analysis of toxic industrial wastes in an Elizabeth, New Jersey clean-up operation to the study of heavy metals concentration in Lima, Peru's drinking water. Unique technical assistance was provided states, municipalities, other federal agencies, EPA Regional Offices, and other branches of EPA to enable them to conduct their missions or achieve agency-wide goals.

PCB Spills

During the summer of 1978, over 200 miles of North Carolina roadways were contaminated by the surreptitious dumping of polychlorinated biphenyls (PCB), a highly toxic chemical compound. ORD was asked to supply technical support to the state and EPA's Region IV in assessing the hazards associated with the spill and in developing a strategy to rectify the problem.

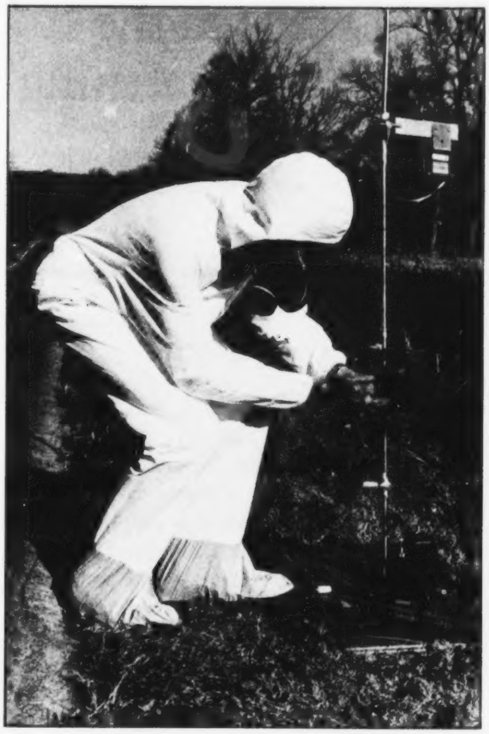
To define the initial problem, ORD scientists took samples of roadside soil from areas thought to be contaminated. The soil was tested for PCB and other impurities. Analysis showed concentrations of PCB in the upper inch of soil that ranged from 5,000 to 10,000 ppm. Chlorinated benzenes were also present.

The ambient air was monitored at three spill sites before, during, and after a test removal of contaminated soil to determine the extent of PCB release into the atmosphere. Ambient air was also monitored in connection with in-place treatment tests proposed by the state. This treatment involved the mixing of activated charcoal, lime, and fertilizer into the soil to dilute and bind the PCBs. Results of all studies showed ambient air PCB levels to be no higher than those found in urban or industrial areas.

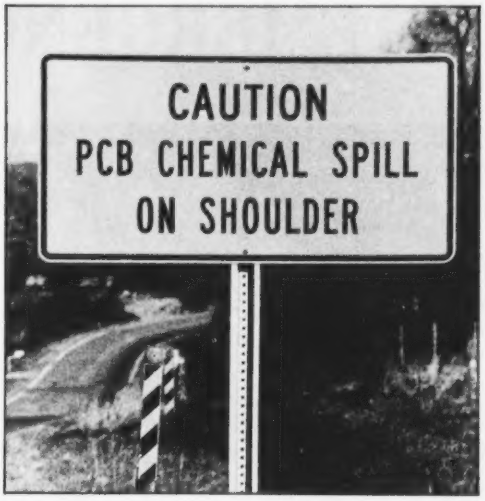
> PCB concentrations were found to be within prescribed standards

Air was also sampled inside houses along the test removal route and near a contaminated roadway. PCB concentrations were found to be well within prescribed standards.

A third air monitoring effort involved study of the air breathed by personnel involved in the tests to remove or treat the contaminated soil in place.



An ORD technician sampling the ambient air at PCB spill site



Road sign along a North Carolina highway

During the test removal phase of the study, PCB levels were below the one microgram per cubic meter level for all but one sweeper operator. During the in-place treatment phase, a number of workers close to the dustier parts of the operation were exposed to PCB levels slightly higher than those proposed by NIOSH as safe for humans.

Blood samples from the test spill removal team were taken prior to the operation to determine baseline levels and to assure that no one was selected for the task that had higher than usual PCB levels.

Studies were conducted on the proposed in-place treatment of PCB by the addition of activated charcoal. Laboratory results indicated that the PCB was transferred from the soil to the charcoal with a 50 to 70% efficiency and that PCB was not leached from either soil or charcoal by water.

Animal studies to determine the effects of activated charcoal on the biological availability of PCB found that activated charcoal does decrease the effects of PCB but does not eliminate them.

Among the conclusions drawn by the ORD scientists was that the primary human hazard of the contaminated soil comes from chronic exposure by intimate contact, e.g., walking over spill areas. Exposure through the air would be negligible, even during removal or in-place treatment, except for workers nearest dust-producing operations. While it was determined that precipitation would not leach PCBs from the soil into nearby streams, their spread by erosion during heavy rains is thought to be a distinct possibility.

The in-place treatment of the soil as proposed by some clean-up participants was not considered effective by ORD scientists who subsequently provided the technical basis for EPA's decision to recommend against it. Rather, ORD advised that the contaminated soil be removed and placed in controlled chemical landfills to eliminate all risks of human exposure.

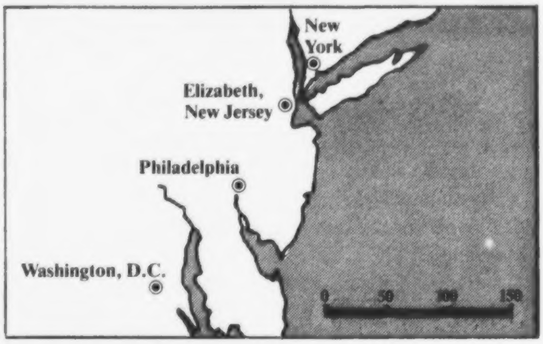
Clean-up

ORD has frequently been called on by state and local environmental officials and EPA regional administrators to provide technical support for the clean-up of hazardous chemical wastes from abandoned dump sites.

In 1977, such support was provided to EPA's Region II which was involved in a clean-up of a defunct toxic waste disposal site in Oswego, New York. When two dikes were assessed as unstable by ORD's sonic dam tester, the Rumble Reader, ORD quickly dispatched its Mobile Physical Chemical Treatment System to treat the toxic water contained in the two lagoons that were threatening Lake Ontario. Overall, a total of 1.8 million gallons of water and waste were treated to alleviate the problem.

In Haverford, Pennsylvania, in 1976, ORD stemmed the leakage of oily wastes into groundwater. In Dittmer, Missouri, ORD participated in a clean-up of an illegal dump area whose leaching wastes were fatal to all living organisms in a nearby stream. And, in 1978, when chemicals that leached from the Love Canal—formerly a waste disposal facility in Niagara Falls, New York, and subsequently developed as a residential area and schoolyard—resulted in human health problems, ORD was immediately called to the scene to analyze the leachate and to specify the treatment technology available for its decontamination.

In 1979, ORD again responded to a Region II request for emergency technical support at a state-sponsored clean-up of a bankrupt hazardous waste industrial disposal facility near Elizabeth, New Jersey. Here, prior to ORD's arrival, a number of workers participating in clean-up operations had been injured due to the improper handling of some of the 40,000 unmarked drums on the site. Using ORD's Mobile Analytical Laboratory, protocols for analyzing the contents of the drums were quickly developed. The resulting rapid and accurate analyses were vital in determining which drums could be safely removed and readily disposed of and which posed yet greater disposal problems. Some of the drums, for example, were found to contain radioactive material, while others housed explosives.



Drums containing radioactive material and explosives were among those at this disposal site in New Jersey

Equipment in support of the Dittmer, Missouri clean-up effort

The 35-foot ORD Mobile Laboratory remained on-site through the initial analysis portion of the operation and was subsequently made available to the State of New Jersey until longer term technical support for the duration of the clean-up could be arranged.

Through the development and refinement of its emergency response and clean-up capabilities, EPA will continue to be able to provide rapid assistance in dealing with the extremely important problems posed by improperly managed hazardous wastes.

Asbestos Sealants

In December of 1978, EPA's Office of Pesticides and Toxic Substances (OPTS) instituted a corrective action for friable (easily crumbled) asbestos in school buildings. It was known at that time that even short-term exposure to asbestos was harmful to the lungs and that long-term exposure often resulted in lung cancer and other related diseases.

Asbestos fibers

ORD was asked to provide technical support in two areas. First, to produce a videotape (see the Information Transfer, page 89) to introduce and summarize material contained in a report on the use of sprayed-on sealants for asbestos fiber control already under way at ORD laboratories. And second, to provide technical support for a series of seminars to be held in all EPA Regional Offices.

By March 1979, the videotape was complete, and over the next three months seminars were held to acquaint regional personnel with the hazards and corrective actions recommended for asbestos contamination. ORD provided the necessary technical support for this work, and conducted a workshop for EPA regional asbestos coordinators and Army, Navy, and Air Force representatives to give them hands-on experience in performing asbestos removal and sealing operations.

As a result of these workshops, EPA personnel are now well informed and equipped to provide assistance to school administrators in the asbestos abatement procedures necessary to protect the health of school personnel and school children.

Children can be exposed to asbestos fibers from insulation material in school buildings

Benzene Contamination of Water

A small Indiana manufacturing plant was the focus of ORD assistance action following an EPA Region V investigation of the plant's drinking water to locate the source of a persistent objectional taste and odor. The investigation led to the discovery of high concentrations of benzene, sulfur compounds, and other chemicals contaminating the private well supplying water to the plant. Because benzene is a known cancer causing material and toxic to blood-forming cells, Region V officials requested ORD technical support to determine if employees had been exposed to this dangerous substance and if any adverse health effects had resulted from this exposure.

An ORD team was mobilized to conduct a comprehensive health evaluation both of company employees and of unexposed workers from a neighboring firm who served as a control group.

Subjects completed a general questionnaire, a medical interview, and donated a blood specimen. An exposure index was developed based on employee water and coffee consumption information and on company employment records. Water and air samples were collected at various locations throughout the plant.

A thorough analysis of medical history and a check of the blood specimens for a variety of functions showed both groups to be in generally good health. Comparison of the exposed and control workers revealed no differences between them in any of the health status indicators measured. Nor were there any suspicious trends found that might be attributable to chemical exposures.

Analysis of air sampling data found benzene at hazardous levels in bathroom air when the showers were running. Here the toxic chemicals in the water posed a triple threat—exposure was possible through swallowing, skin absorption, and air inhalation of the water in its evaporated state.

Nevertheless, the technical support team did not detect any adverse health effects, probably owing in large part to the contaminating sulfur compounds present in the water which gave it its pungent odor and served as an early warning indicator that something was amiss. The plant is now using an alternate water supply while the source of the chemical contamination is under investigation.

Benzene, a well-known cancer-causing agent, was found in an Indiana plant's drinking water

Neskowin, Oregon

When nearly 200 people came down with acute gastrointestinal illness in Neskowin, Oregon, a small city in EPA's Region X, ORD was called in to provide technical support to the city's privately-owned and operated water supply following determination that the supply was the probable cause of the illness.

An ORD engineer identified serious deficiencies in the city's water system

ORD's response in emergency assistance cases such as this is to identify the causative agent, determine its route of entry into the water supply, provide technical support, and make recommendations to assure the event does not recur. An ORD sanitary engineer working with Region X personnel identified serious deficiencies in the city's water system, including inadequate chlorination. Improvements were recommended but when the water supply owner and operator proved reluctant to implement them, enforcement proceedings ensued under the Safe Drinking Water Act. The ORD engineer who investigated the initial outbreak was called as a witness at the proceedings. He described deficiencies in the system, prescribed short-term improvements necessary to ameliorate the immediate health effects, identified long-term improvements to remedy the general in-

Seattle
Portland
Neskowin

adequacies of the system, and estimated the health risk involved with continued operation of the system without improvements.

Incorporating the ORD technical advice into its order, the court ruled that the water utility must make the improvements, a precedent-setting decision, in that it was the first incidence of court enforcement in support of the Safe Drinking Water Act. It also served notice to recalcitrant water system operators that health risks from inadequate and poorly-operated water supply systems could not and would not be tolerated. As an outgrowth of public concern and concurrent with the court action, Neskowin citizens formed a group to establish a publicly owned water supply for the city. Federal funding was obtained and currently all signs point to upgraded water quality for the community.

Land Treatment

Land treatment—the application of wastewater to soil for irrigation and fertilization — has been practiced for centuries around the world, but only in recent years has it become an accepted alternative in the United States to conventional wastewater treatment processes. Compared to conventional processes land treatment offers a number of advantages including low initial cost, lower operating costs, potential for revenue to offset operating costs, and low energy requirements.

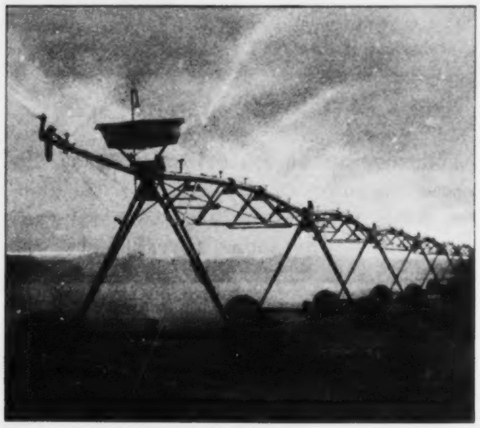
Aerial view of sewage treatment plant in Oklahoma

Yet despite its many advantages proven in the laboratory, in pilot plants and in full-scale operation, land treatment has not begun to reach its potential as a wastewater treatment alternative. Part of the problem stems from lack of public acceptance. The public tends to equate the process with "sewage farming," unaware of the developments in soils treatment technology made during the last decade. Farmers, who stand to reap significant benefits from land treatment, have also shown little interest by and large because they have not been made aware of the increased crop yields, fertilizer savings, and water conservation experienced by those who have already joined in joint city-farmer land treatment arrangements. Some state water pollution control agencies still have restrictive design criteria that do not take into

Land treatment facility near Phoenix

consideration new land treatment technology, while many community officials simply feel more comfortable with older, more traditional methods of wastewater management.

In 1978, EPA formed two pilot program Land Treatment Task Force Teams to operate in EPA Regions VI and VII. The teams have two main functions: (1) to encourage land treatment where practicable, and (2) to assure that selected land treatment options are designed and operated at high efficiency levels. To this end, recent efforts were concentrated on providing technical support to consulting engineers, community officials, and state water pollution control agencies.



Center-pivot irrigation boom spraying treated wastewater in Oklahoma

Consulting engineers are the key to implementation of innovative or alternative approaches to water pollution control problems because they are the people who propose pollution solutions to local governments. To inform the engineers and to win their support for land treatment, three land treatment design workshops were held, resulting in certification in the two regions of over 100 engineers. These certified engineers have generally proposed land treatment where appropriate in the nine states of Regions VI and VII. The task force also worked with state water pollution control agencies to update out-of-date design and policy criteria that tended to discourage land treatment and ignore present state-of-the-art soils treatment technology.

To better educate the public, the task force produced a 20-minute slide/tape show that presents seven land treatment case histories. Additionally, task force members attended public meetings on land treatment to provide information and answer questions.

Results of task force efforts are already in evidence as state and local officials, consulting engineers, and the general public are demonstrating enthusiasm for land treatment and giving the procedure the consideration it deserves.

Aerial Imagery

When technical support was required to prepare pulp and paper mill water quality enforcement actions, ORD developed an information-gathering system that combined aerial photography and multispectral scanning technology with a comprehensive mill process and production data base. Thus, in 1979, EPA was able to photograph and obtain multispectral scanner imagery of pulp and paper mill sites from the air for a clear assessment of site pollution sources and environs. Information gathered from these overflights was then correlated with process and production data and presented in an "atlas" format for review and strategy planning. The atlas also serves as a basis for discussions with industry officials about potential pollution problems.

EPA conducted these flights during various tidal and stream flow conditions and at several altitudes to evaluate pulp and paper mill waste discharge plumes as they mixed with receiving waters. The timing and variations in rates of discharge were established. Water turbidity and color were analyzed and ground-collected data were used along with the image-collecting overflights to derive reference points for fully describing plume characteristics.

The ORD-developed technical support system presents EPA with a clear information base for making informed enforcement decisions, and the comprehensive evidence necessary to convince industry officials and state and local agencies of the validity of these decisions.

Aerial photograph of a pulp mill

Secondary lead smelter

Standards for Secondary Lead Smelters

To facilitate the future joint implementation of the EPA and OSHA lead standards, an ORD/NIOSH team traveled to Denmark in 1978 to measure the sources and concentrations of lead emissions from a secondary lead smelter. The plant uses advanced administrative and engineering controls designed to meet environmental and occupational lead standards and, as such, represents the world's best example of airborne lead control for secondary lead smelting operations.

Activity at secondary smelters involves the reclaiming of lead from scrap and batteries, a process carried out by mixing lead with coke, slag, iron, and lime in blast furnaces. The resulting hard lead is either cast or refined to produce soft lead (i.e. lead that contains no trace elements) for use in lead products or to make lead oxide for batteries.

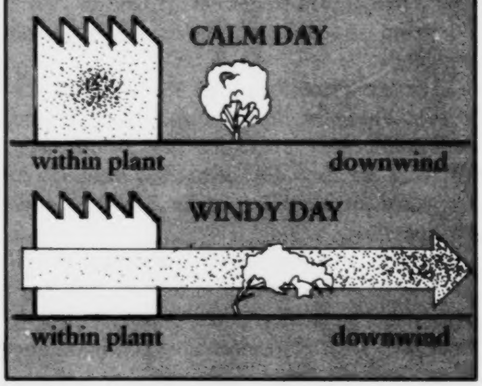
The most dangerous emissions from such smelters result from dust, particulates, fumes, and gases that are not collected or that escape from collection devices or transport ducts. These uncollected emissions can produce high levels of exposure to lead, antimony, sulfur, and chlorine compounds inside the plant as well as downwind from it.

At the Danish facility, ground-level concentrations were shown to be substantially below those found in domestic plants and, although relatively lead-free areas were identified within the smelter building, some employee exposures in the working zone were above OSHA's four and five year goals for the secondary lead industry. Nevertheless, by permitting employees into the "dirty" zones only as necessary, the OSHA 8 hour exposure levels could probably be met.

Following the Danish evaluation, the ORD/NIOSH team investigated a domestic facility, typical of U.S. "pre-control" secondary lead smelters. Here, emissions and exposure rates were well above current standards, and respirators were required for personnel protection. It was also found that weather played an important role in these emission and exposure rates. Windy conditions tended to cleanse the air inside the plant, while calm days permitted air to stagnate and lead levels to remain high. However, the higher winds carried more dust from the plant to be disbursed into the surrounding areas.

Ultimately, this ORD research may provide OSHA and NIOSH with a firmer scientific base upon which to propose future lead control strategies.

LEAD CONCENTRATIONS FROM SECONDARY SMELTERS



Heavy Metal Recovery

The Boliden Metal Corporation in Sweden is the only nonferrous smelter in the world that makes use of full-scale sulfide precipitation to treat heavy metal wastes. To assist EPA offices in the preparation of a sulfide precipitation system design manual, ORD undertook an extensive sampling program in 1979 to determine the Swedish system operating parameters and to evaluate its performance.

Characteristic of the system is the addition of sodium sulfide to plant and process runoff and wastewaters to precipitate heavy metals. By adjusting the acidity of the solution, the selective precipitation of heavy metals for recovery can be accomplished. Though this aspect of the process is not in current practice, the Boliden plant is capable of separating arsenic, copper, zinc, mercury, and cadmium sulfide. The plant now processes over 50,000 gallons of plant wastewater per hour. The sulfide sludge that remains is retained for possible future metals recovery.

ORD test data indicated very effective removal of heavy metals

ORD test data indicated generally very effective removal of heavy metals but identified some occasional resistance of zinc and arsenic to the precipitation process. It was concluded, however, that these fluctuations were probably caused by improper control of solution acidity, sodium sulfide dosages and H_2S/SO_2 reactions, and by poor process control.

The data generated in this ORD study will be used to support EPA effluent limitations for nonferrous smelters. Additionally, it provides an insight into a sophisticated treatment system that may eventually play a recycle/reuse role in similar U.S. industries.

Peru

At the request of the Pan American Health Organization (PAHO), an ORD scientist visited Peru in December 1978 as a member of a two-man investigative team. The purpose of the visit was to evaluate the extent and impact of metal pollution in surface waters of the Mantaro River Basin and to determine the effects of a planned water-diversion project from that Basin on Lima's drinking water. Protocols were also to be developed detailing the steps necessary to protect the health and welfare of Mantaro River Valley inhabitants.

It became readily apparent to the visiting team that a serious pollution problem existed in the river basin. Peru, rich in minerals and ore, is a multibillion dollar exporter of copper, lead, zinc, silver, and other metals; river basin pollutants reflected these extensive mining and smelting activities, with reported levels found to be as high as, or higher than, levels that have already resulted in major human health consequences in other areas. The air carries elevated levels of arsenic, lead, and sulfur dioxide; the water, used to irrigate local farmland, contains high concentrations of heavy metals.

The planned Lima water diversion project will include construction to decrease the discharge of heavy metals into the river and to bypass some of the river's heavily contaminated sediment banks. It was not clear to the visiting team, however, whether such actions would be sufficient.

The team also determined that more information was required before a full assessment of the pollution situation could be made. Measurements of metal concentrations in water, soil, food, and in the tissues, blood, and urine of humans would have to be established, and epidemiological studies would have to be made to determine the extent to which humans are affected by these metals. The visiting team prepared protocols detailing methods for generating this information.

ORD believes that such international environmental assistance often provides new insights into the solution of similar local problems while it also contributes to the inevitable worldwide acceptance of a shared global environment.

The following ORD components contributed to the research described above:

- Office of Health Research, Health Effects Research Laboratory, Cincinnati, Ohio and Research Triangle Park
- Office of Environmental Engineering and Technology, Industrial Environmental Research Laboratories, Cincinnati and Edison
- Office of Environmental Processes and Effects Research, Kerr Environmental Research Laboratory, Ada
- Office of Monitoring and Technical Support, Environmental Monitoring Systems Laboratory, Las Vegas

ENERGY

ORD researches the environmental and economic effects of existing and emerging energy technologies

1979 was a year where again the necessity for a comprehensive national energy program became all too evident. Rises in the cost of heating fuel and shortages of gasoline at the pumps were only the most obvious indicators of the need for an increased energy supply. Heartening is the fact that the resources exist within our boundaries to alleviate many of our energy problems. A major remaining issue is one of cost—not only the cost of the process to produce this energy but also the cost to the environment. What are the ecological prices to be paid if our shale is to be retorted? Our coal mined and gasified? And are those costs affordable when measured against the benefits derived?

Recent EPA research into the environmental effects of energy production and use explores these costs—from both the environmental and a dollars and cents standpoint. Overall, the program seeks to monitor, control, develop, verify, and improve existing and emerging energy sources and technology. The following are some highlights of this effort.

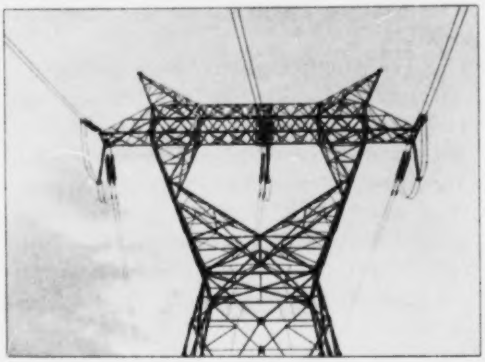
Conversion from Scarce Oil to Plentiful Coal

EPA's response to President Carter's mandate to turn from imported oil to domestic coal to fire many of the nation's power plants was to accelerate research into the viability of such a conversion, both from a cost standpoint and from an environmental one. 1979 produced noteworthy results on both fronts.

A power plant can save $14 million per year by making the conversion

The cost. To produce 1 million Btu's of heat, the cost of oil is $5.18, based on a price of $30 per barrel. To produce the same 1 million Btu's of heat, the cost of coal is $1.30, based on a price of $30 per ton. Extensive EPA research has demonstrated that it would be financially attractive for a power plant to convert from oil to coal, even if the costliest pollution control equipment is required.

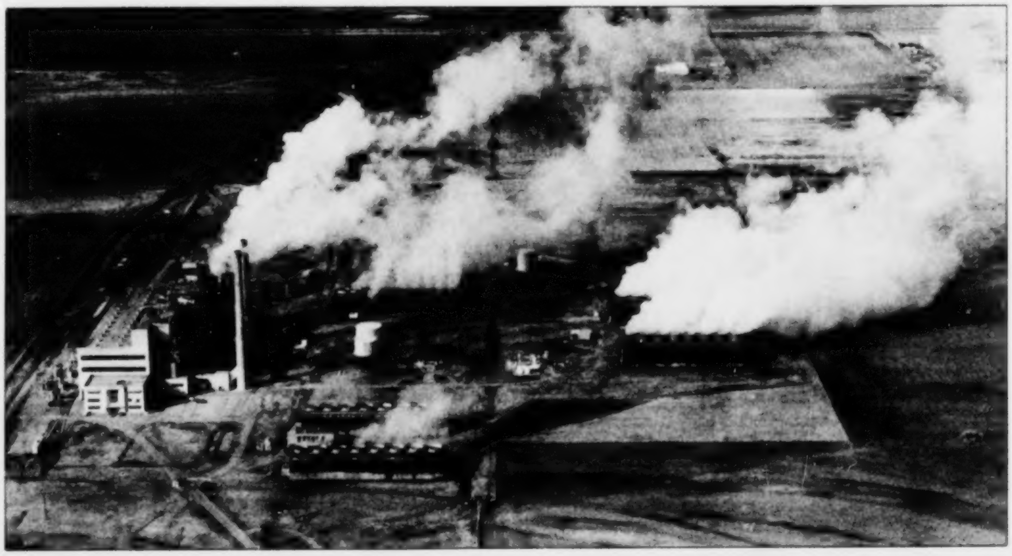
By example, a power plant could save 0.5¢ per kWh by making the conversion and using the best available scrubber, one that is 90% efficient in reducing sulfur dioxide emissions. This translates to a savings of over $14 million per year for the average size of electric generating plant being built today. Where less stringent scrubber controls are required, savings would increase, and, in those states where emissions standards could be met without scrubbers, yet greater savings could be realized. In fact, according to conservative EPA projections for the burning of high sulfur coals, a savings of 1/5 of a cent per kilowatthour will accrue to a utility that retires a modern oil plant and replaces it with a new coal facility outfitted with the best scrubber.



A nickel per kilowatt hour savings is possible through oil-to-coal conversion

Currently, 26% of all U.S. power plants are oil-fired and 39% coal-fired; the rest depend on either natural gas, nuclear energy, or hydropower.

The environment. Although scrubbers are expensive, this expense must be viewed both in terms of alternative energy sources (i.e., oil) and in terms of total environmental impact. Notably, in the testing of a 10-MW industrial boiler, it was demonstrated that the national goal of the extensive conversion of oil-fired boilers to coal could be accomplished *without* the unacceptable degradation of the environment, a conclusion predicated, however, on the careful application of pollution control technologies.

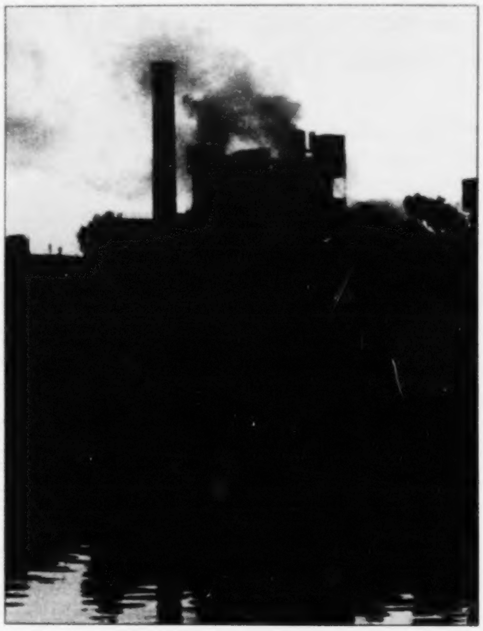


A coal-fired power plant in action

The following are among the significant test results:

- Flue gas desulfurization systems (scrubbers) can cause sulfur oxide emissions from high sulfur *coal* applications to be less than emission levels from the combustion of low-sulfur *oil*.
- The quantity of particles exhausted from coal-firing was 56 times as great as from oil-firing, with oil-fired particles smaller and more difficult to remove. After scrubbing, however, quantities from coal-firing were only 1.4 times as great.
- NO_x and CO emissions before *and* after scrubbing were three times as high for coal than for oil, not an unexpected finding, since the scrubber does not remove these pollutants and oil-firing produces smaller amounts of them. Resulting NO_x levels were greater than those permitted by National Ambient Air Quality standards, thus pointing to the need for some manner of NO_x controls for coal-fired plants.
- SO_3 emissions were about 1.5 times greater from oil-firing than from coal-firing.
- Greater quantities of heavy metals and trace elements were found to remain in the scrubber cake after coal-firing; however, disposal of the scrubber cake from both oil- and coal-firing would require care to avoid contamination of groundwater through leaching.
- Trace element emissions from the scrubber were generally higher for coal; however, oil-firing produced 60 times as much cadmium.
- Among trace element emissions, cadmium and molybdenum are predicted to produce the greatest burden in living plant tissue; oil-firing was predicted to cause a ten-fold increase in cadmium concentrations and coal-firing to cause a thirty-fold increase in molybdenum concentrations. Cadmium is thought to be considerably more dangerous, however, and the study indicated clusters of oil-fired plants could produce levels of cadmium in living plants that could ultimately be injurious to man.

EPA research demonstrated that it would be economical for a power plant to convert from oil to coal



Enhanced Pollution Control—Adipic Acid

As the nation returns to coal as a primary energy source, increasing concern is being voiced about the by-products of such combustion. Will the future be a repeat of the nineteenth century when cities were choked by fumes and the air was thick with sulfur? Not likely, with today's control technologies—particularly for the control of sulfur dioxide (SO_2), the major pollutant in coal combustion.

Two 1979 reliability runs of coal-fired boilers indicated precisely how far we have come in controlling the offending by-products of coal combustion. The purpose of these tests was to demonstrate the effectiveness of adipic acid when used as an additive in flue gas desulfurization (FGD) lime/limestone scrubbers for the removal of SO_2. The acid itself is a readily available organic compound in general use today in the manufacture of nylon and sometimes used as a food additive.

The first reliability run involved the use of adipic acid in a conventional prototype limestone scrubber over a 28-day test period. SO_2 removal averaged 96%, with a 24-hour emissions average of only 0.26 lbs/10^6 Btu. This figure falls well below the 1979 revised EPA standards of 1.2 lb/10^6 Btu. Moveover, these results far exceeded the requirements under the 1979 revised EPA performance standards for new plants.

The second adipic acid reliability run involved a more advanced prototype limestone scrubber, one that forced the oxidation of various elements in the remaining sulfur sludge to their less harmful oxides. Over a 112-day test period SO_2 removal averaged 96%, fully 10% greater than in similar tests without the additive. The 24-hour emissions average was 0.20 lb/10^6 Btu, again, far exceeding the requirements under the new EPA standard. Scrubber reliability over the test period was 98.9%.

In addition to demonstrating full compliance with the new EPA performance standard, the second test also demonstrated that waste sludge can be completely oxidized through the use of adipic acid, thus making sludge disposal easier and less costly. And since adipic acid use requires less limestone to attain a given degree of SO_2 removal, the quantity of the waste sludge produced is also diminished. Through use of adipic acid these improved costs and performances can be realized not only by new plants, but by existing plants as well.

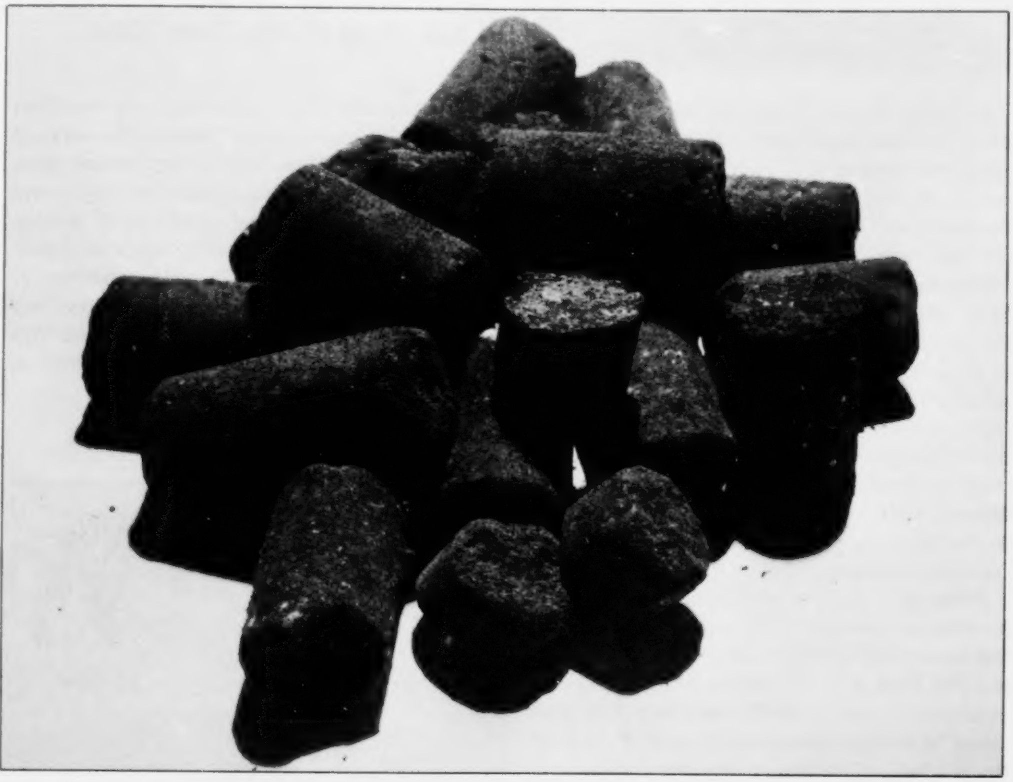
Exceptionally high operating reliability factors in these tests can also be attributed to the use of adipic acid. The addition of the compound enhances the effectiveness of a flue gas desulfurization system's scrubbing alkalis — lime or limestone. With the high alkali utilization brought about by the use of adipic acid a number of operating problems common to FGD systems with low alkali utilization can be avoided. Adipic acid has been demonstrated to stabilize the effects of rapid or varied changes in SO_2 input into the scrubber system. Thus, a more constant outlet level of SO_2 is maintained in spite of fluctuations in boiler load or coal composition.

Preliminary cost assessments indicate that the use of adipic acid will not increase scrubber costs, but may, in fact, decrease them slightly. One factor in the cost analysis is that the efficiency of the additive permits the use of limestone rather than the more energy-intensive lime to achieve the desired removal efficiency. The use of forced oxidation systems to complete oxidation of the sludge and the diminished quantities of waste sludge also figure into the cost equation.

Subsequent 1979 studies demonstrated no secondary environmental effects from the use of adipic acid. Tests of the scrubber solution and sludge for harmful by-products also revealed no problem.

Limestone Coal Pellets

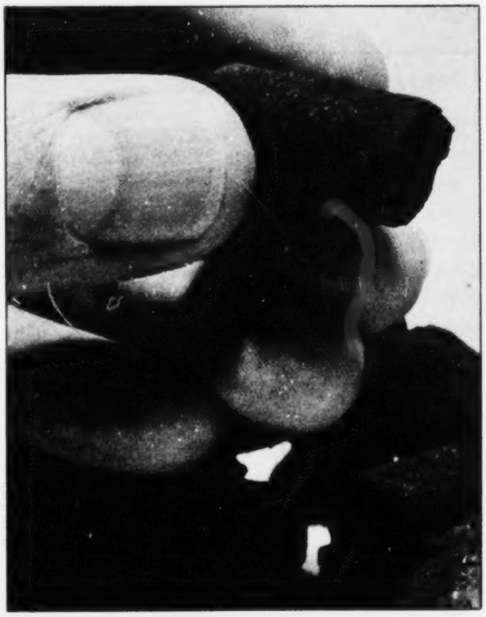
An operational characteristic of stoker boilers is their relatively low emission of nitrogen oxides, carbon monoxide, and gaseous hydrocarbons. Because particulate matter emitted from these types of boilers can be controlled by existing technology the only environmental deterrent to using high sulfur coal in stoker boilers is their tendency to produce high SO_2 emissions. Recent ORD tests, however, demonstrated a marked reduction in SO_2 emissions when stoker boilers were fired with a fuel pellet composed of coal and limestone. While it is yet to be established exactly how limestone captures sulfur more efficiently when it



Limestone coal pellets

is integrally mixed with coal, the fact is that it does, and tests continue in its use in ORD's program to provide incentives for industry to burn coal in an environmentally acceptable manner.

In 1978, Phase I of the study evaluated a 50% limestone/50% coal pellet in a small scale (20-hp) spreader stoker boiler. The combination was found to be 77% effective in capturing the sulfur content of the fuel. Phase II confirmed the sulfur capturing potential of the fuel pellet in an 8-hour test run in a full-scale spreader stoker boiler. Sulfur capture with the 50%/50% pellet was 74% effective.



Individual pellet size can affect fuel performance

In 1979, Phase III research was initiated to study optimum pellet formation, production, and operation, both from a performance and a cost standpoint. Although a number of different boilers eventually will be used in pellet fuel evaluation, the basic testing system to screen out likely pellet candidates involved the use of a relatively small, batch combustor called a tubular fixed-bed reactor. Several hundred experiments were performed in this combustor to evaluate the parameters that affect pellet fuel performance. These parameters include coal/limestone ratio, pellet size, coal type, binder material, and limestone type. As a result of these screening tests, a material for binding the limestone to the coal was evolved which resulted in a sulfur capture of as high as 87% using a 66% coal/33% limestone pellet.

Pellet fuels made by several different forming methods are currently being produced for evaluation in the 20-hp spreader stoker boiler. Forthcoming data from these test series will result in the selection of a pellet formulation that will be produced in tonnage quantities for an 8- to 10-hour test in a full-scale boiler. A complete environmental assessment of the pellet fuel operation will then be developed from this test to complete the Phase III operation.

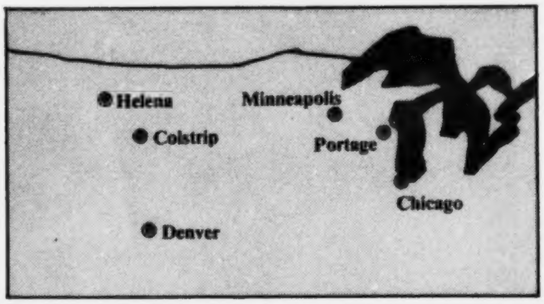
Cost analysis of pellet fuel technology has indicated that preparing the fuel, based on a projected 60-ton/hr processing plant, would only add $15/ton to the cost of the coal; substantially below the cost of the wet scrubber technologies available for industrial boilers today. Thus, further development of pellet fuel technology could provide a cost-effective alternative control technology for industrial and commercial boiler operators who do not have the capital or the trained personnel available to use these scrubber systems, still the most effective method of SO_2 control.

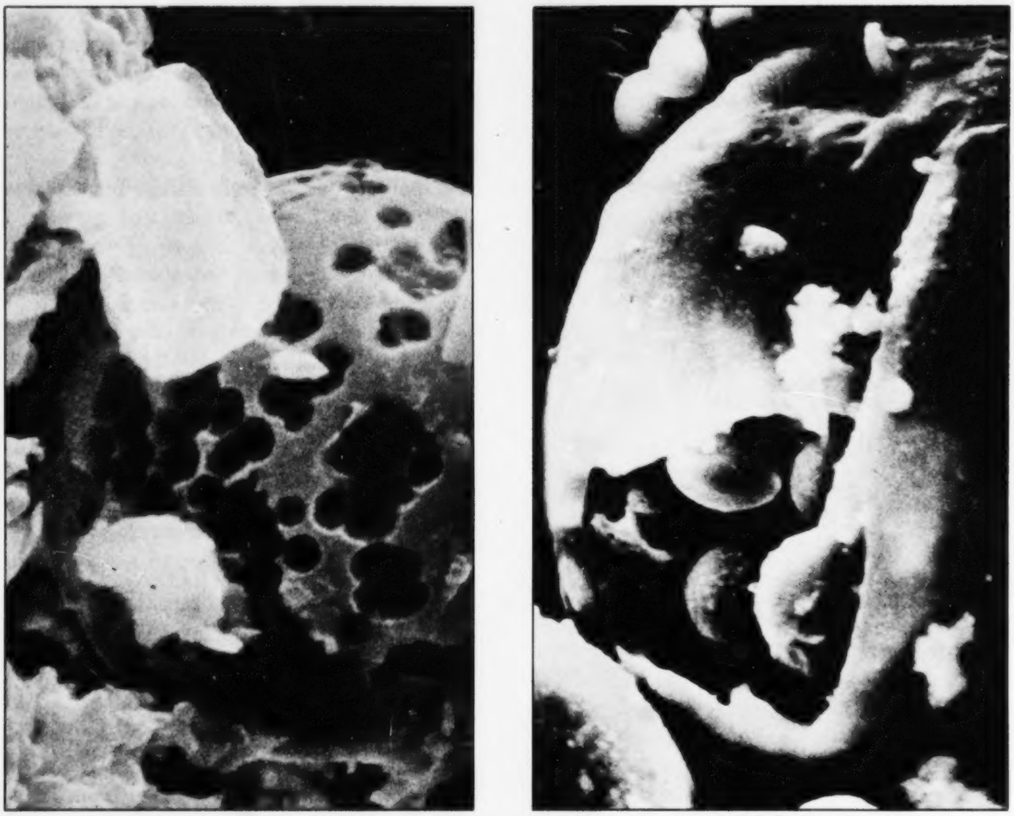
Future ORD study will involve the preparation of 4000 tons of the best pellet formulation for a 30-day test on a large stoker boiler. Results will establish the full-scale environmental and operational performance of the technology, while allowing EPA the opportunity to evaluate this technology in relation to the new source performance standards being developed for industrial boilers.

A program is currently in the planning stages to expand the pellet fuel concept to a wider range of coals and boiler types. Since essentially all the technology to produce these pellet fuels is already in existence, success of this research could mean major use of the pellet fuel process in America's energy future.

Environmental Impact of Coal-Fired Power Plant Sites

An ongoing study monitoring two coal-fired power plants—one in Colstrip, Montana and one in Portage, Wisconsin — has yielded some interesting environmental results. Notably, it was found that only moderate quantities of gaseous emissions, trace metals, and fly ash were deposited close to the plants. Far larger quantities of these pollutants, however, were transported well beyond the plants' vicinity to areas where they finally settled to the ground, some in the form of acid precipitation.

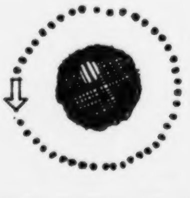




Fly ash sphericals from coal combustion

The study also revealed that the existing bulk analysis method for monitoring fly ash particles was not adequate. Rather, it was found that the key to the particles' effects lay not in bulk, but on their surface where readily transferable or extractable toxic components gather. A comparison of bulk-to-surface analysis of a single sample is highly revealing:

BULK-TO-SURFACE COMPARISON OF FLYASH

		
	Surface (μg/g)	**Bulk (μg/g)**
Lead	2700	620
Thallium	920	28
Chromium	1400	400
Zinc	14600	1250
Arsenic	1500	600

Fly ash was also shown to host complex organic compounds which left the stack as vapor and then attached themselves to the particles' surface. Some fly ash particles, it was found, resembled "time release" capsules—large particles enclosing several smaller ones. Yet another finding in the fly ash studies was that the particles from a specific power plant had a unique "fingerprint" based on their chemical composition. This fingerprint permits their identification in environmental samples in the presence of fly ash from other sources.

A second major finding of the overall study concerned the effect of the Wisconsin plant's cooling pond on the nearby Wisconsin River. Owing to a 9-foot difference in water levels, and a sandy soil in the meadow that separated them, the pond leaked water into the river, an anticipated phenomenon. What was not anticipated was the six-month lag time of the leakage which resulted in the pond water that was heated during the summer leaking into cold winter river water. This elevation of temperature produced widespread damage to perennial plants in the meadow and river, and upset spawning activities of a number of fish species. Today damage continues with the addition of a second power plant unit causing higher cooling pond temperatures and creating widespread changes. Whatever steps are taken to alleviate the problem, it is expected that it will be at least a decade before an ecological steady-state can again be achieved.

Monitoring in the cooling pond continues for copper, arsenic, and other compounds that might find their way into the sediment and into the food chain. Sources for these pollutants include pipes, conduits, and chemicals used in plant construction and operation.

Pollutant sources include pipes, conduits, and chemicals used in plant construction and operation

Additional study has been made of cooling pond organisms (mainly fish) for the presence of toxic chemicals associated with coal combustion that might be hazardous in the event of secondary consumption, i.e., man eats fish. The identification of a few key indicator chemicals could serve as monitors for the banning of fish for human consumption. To date, few of these chemicals have been found, and none in any quantities to be of concern.

The study also developed a regional air quality simulation computer model capable of measuring the dispersion of plant exhausts from a number of sources and in a number of weather conditions. Wet and dry deposition of pollutants can also be measured to assess the impacts of acid precipitation. Recent use of the model in northern Minnesota/ western Ontario border areas allowed researchers to estimate the deposition of emissions associated with a single site. This model may be generalized for use.

As an outgrowth of study data, a protocol has been developed for the evaluation of energy and environmental policy issues in power plant siting. Also, over the course of this research advances have been made in the overall science of energy impact evaluation. In the past, *either* an ecosystem approach (one that considers the impacted system as highly interconnected) *or* a mass-balance approach (one that follows chemicals into the plant and traces them to their ultimate effect) was used. Today as a result of the study, planners finally are looking to integrate both approaches for a more comprehensive and realistic measure of the effects of energy development.

Low NO_x Burner Field Testing

Under EPA contracts, a coal burner low in nitrogen oxide emissions has been developed. The burner is called a distributed mixing burner and was designed for use in large, pulverized coal-fired boilers. NO_x reduction comes as a result of the burner design which provides staged addition of air to the coal.

Coal is introduced with primary air into the boiler where it reacts in a fuel-rich/ oxygen-poor environment to produce fuel nitrogen inter-

Selected site for a coal-fired power plant mediates (XN). The introduction of secondary air then creates a gradual leaning out of the fuel environment and brings about chemical reactions that serve to convert the XN species predominantly to innocuous N_2. The addition of tertiary air to reaction products establishes a low emissions burnout zone.

In 1979, the burner was tested at an experimental facility at a scale comparable to practical burners. NO_x emissions from bituminous coal were found to be at or below 0.2 lbs of NO_x (as NO_2) per 10^6 Btu, which is significantly below levels currently produced in pulverized coal-fired boilers.

Small-scale, fuel-screening experiments performed to help generalize burner designs to assure their compatibility with a full range of U.S. fuels indicated that a variety of coal properties have significant effects on NO_x emissions. In a test of fifteen coals, it was established that the percentage of nitrogen alone in coal does not necessarily correlate to eventual NO_x emissions. Rather, other more subtle factors are at play, such as the distribution of the nitrogen in the coal. In an experiment with five coals having essentially the same nitrogen content, it was further found that NO_x emissions varied by over a factor of 1.5, which translates to a difference of between 800 to 1200 parts per million (ppm) of NO_x emitted to the air. Under staged combustion conditions the relative ranking of the five coals by their NO_x emissions remained the same, but the emission difference between them was reduced to less than 100 ppm.

A field study was also initiated to evaluate the burner's performance over an 18-month period. In 1979, field study work concentrated on the selection of host sites and preliminary engineering design for prototype boilers. Currently, an industrial-sized burner fabricated under the ORD program is being tested at the experimental facility to optimize its mechanical design and emission performance in preparation for the first boiler installation anticipated for the spring of 1980.

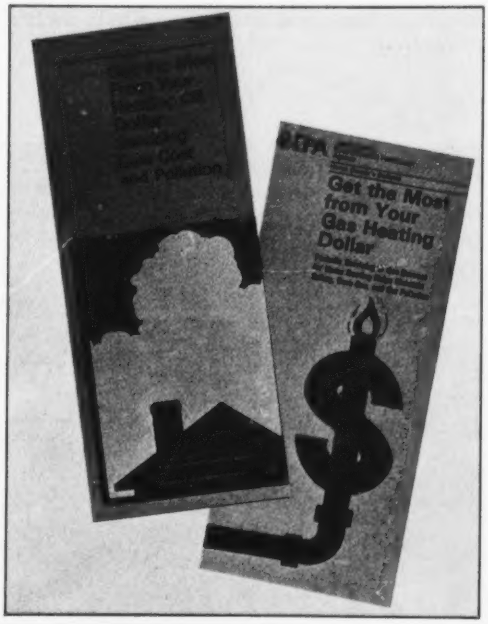
Home and Service Guides for Gas Furnaces and Water Heaters

Homeowners and commercial users of gas-fired space and water heaters can learn and benefit from two guides issued in 1979 by ORD. The two publications discuss the optimal adjustment of gas furnaces and heaters as well as addressing the issue of safety.

Guidelines for Adjustment of Atmospheric Gas Burners for Residential and Commercial Space Heating and Water Heating was written for use by experienced service technicians. By following the step-by-step procedures outlined, the technician will be able to adjust gas-fired equipment to minimize air pollution, maximize efficiency, and ensure safe, reliable operation. The 30-page guide was reviewed by industry representatives and can be used in conjunction with manufacturer's service instructions and as a training guide in advanced burner service courses.

Get the Most from Your Gas Heating Dollar was designed for use by the homeowner. Written in less technical language, this brochure describes how the novice can visually inspect a gas flame to determine whether the burner needs servicing. To date, over 200,000 copies have been distributed by EPA's Office of Public Awareness.

Companion guides were previously issued for residential oil burners. *Guidelines for Residential Oil-Burner Adjustment* was written for service technicians, and a homeowner's brochure, first printed in 1977 and reprinted in 1979, is entitled, *Get the Most from your Heating Oil Dollar – Servicing Cuts Cost and Pollution.*



Other guides which have been published include: *Guidelines for Burner Adjustments of Commercial Oil-Fired Boilers*, *Guidelines for Industrial Boiler Performance Improvement*, and *Reference Guidelines for Industrial Boiler Manufacturers to Control Pollution with Combustion Modification*.

Early in 1980, *Guidelines for NO_x Control by Combustion Modification for Coal Fired Utility Boilers* will be published. The guide is intended for use by engineering personnel and boiler operators responsible for reducing NO_x emissions from new and existing coal-fired utility boilers.

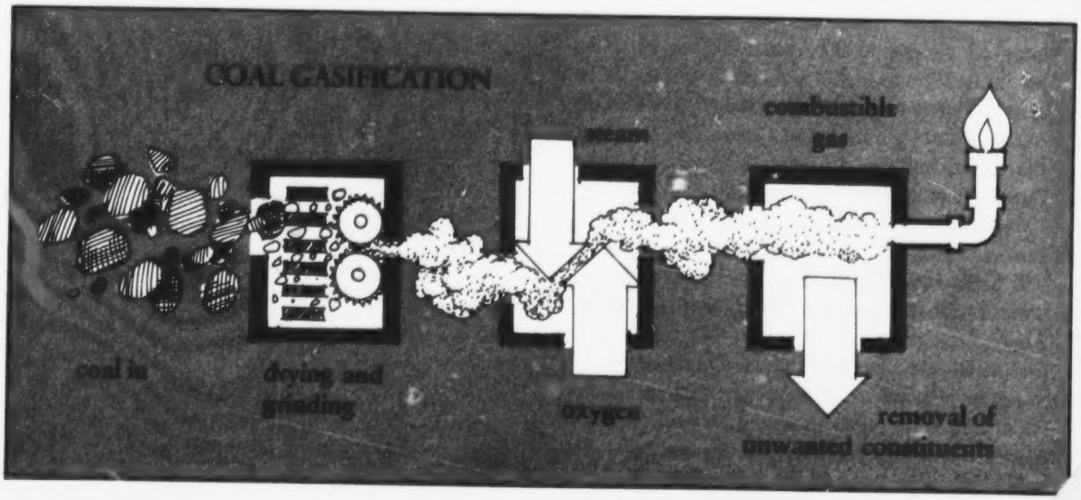
Coal Gasification

The creation of gas from coals is not only a method of obtaining synthetic fuel gas, but is also the first step in many coal liquefaction processes that turn the coal to a gas and then to a variety of synthetic liquid fuels including gasoline. Consequently, it is expected that coal gasification will play a significant part in the energy future of the United States.

Well aware of the need for adequate knowledge of the health and ecological effects of gasification wastes, ORD awarded a cooperative research grant to North Carolina State University (NCSU) to construct a coal gasification test facility to study various techniques for the removal of unwanted contaminants from gases generated by the process and to identify quantities of pollutants and the point of their potential discharge into the environment. Completed in 1978, the facility represents the state-of-the-art in automated plant operation and data acquisition and features a modular type design which allows selection of any of four different pollutant gas removal systems to be studied at one time.

Technician taking samples at coal gasification facility at North Carolina State University

The gasification process itself involves drying and grinding coal and feeding it into a chamber where it comes into contact with steam and air or oxygen at high temperatures and pressure. The gasified coal that results is then further processed to remove unwanted constituents from the product until it becomes the gas that is being sought. This cleaning ranges from the removal of solids to the removal of acid gases. Since coal is made up of approximately 20% unwanted constituents, the resulting clean-up job is a big one.



However, the NCSU facility has been designed to handle the clean-up required. A cyclone removes solid materials and two types of scrubbers remove liquids and tars. An acid gas removal system consists of an absorption unit in which solvents absorb the acids, and a stripper tower where the solvent is cleaned and regenerated.

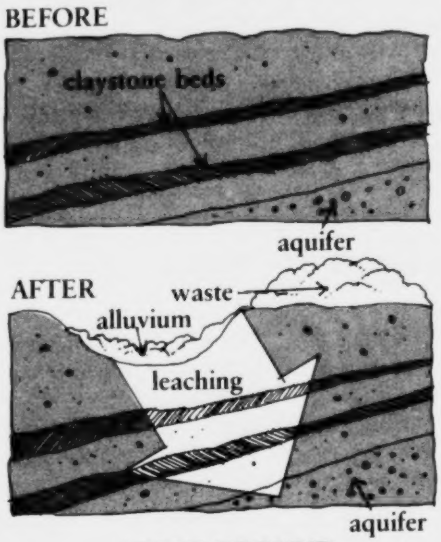
In this first full year of the facility's completion, the initial goals of making the plant 100% operational and of completing a preliminary experimental gasification program using coal char as feedstock were successfully attained. Future information developed from the clean-up test facility will be used to guide EPA in setting emission limitations and should aid commercial process developers in designing environmental control systems for what promises to become a major new United States industry.

Oil Shale Groundwater Monitoring

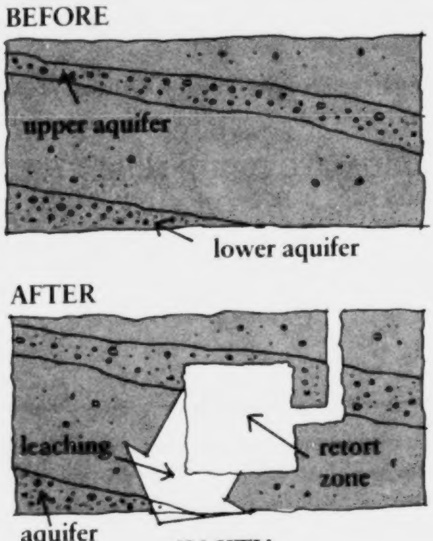
Substitute petroleum products recovered from western oil shale are expected to play an important role in supplying future energy needs. Of the approximately 4,000 billion barrels of oil contained in Utah, Colorado, and Wyoming shale deposits, as much as 1,800 billion barrels may be recoverable; not, however, without significant impact on groundwater quality. In the event of surface-mined shale, for example, millions of cubic yards of spent shale—the material remaining after the shale oil has been extracted—will be deposited adjacent to production areas, providing the potential for leaching of chemicals from this disposal pile into subsurface water and eventually into surface streams. With shale mined *in situ* (processed underground) the spent shale is left underground where the potential exists for wastes to come into contact with adjacent supplies of subsurface water. In either case, the major threat of pollution to groundwater from the mining of shale comes from the spent shale itself, rather than the oil that is drawn from it.

> The major source of groundwater pollution comes from the spent shale itself

POTENTIAL IMPACTS OF OIL SHALE EXTRACTION



ABOVE GROUND



IN SITU

ORD is charged with the responsibility of developing, testing, and verifying groundwater monitoring techniques capable of dealing with this potentially massive pollution source, and in January 1979, issued a major oil shale project report. The report presented a priority ranking of potential pollution sources resulting from the underground mining, surface retorting, and the disposal of oil shale. The report specifies that to rank a pollutant, data must first be gathered and evaluated in order to identify the pollution's source and the pollutant itself and to assess the infiltration and mobility of this pollution in the subsurface. The criteria then used to develop priority rankings are: (1) mass of wastes, and pollutant persistence, toxicity, and concentration; (2) potential pollutant mobility; and (3) known or anticipated harm to water users.

This report is only the first phase of a larger research effort to design a complete monitoring program for all the potential environmental impacts of oil shale on groundwater quality.

Alcohol From Wastes

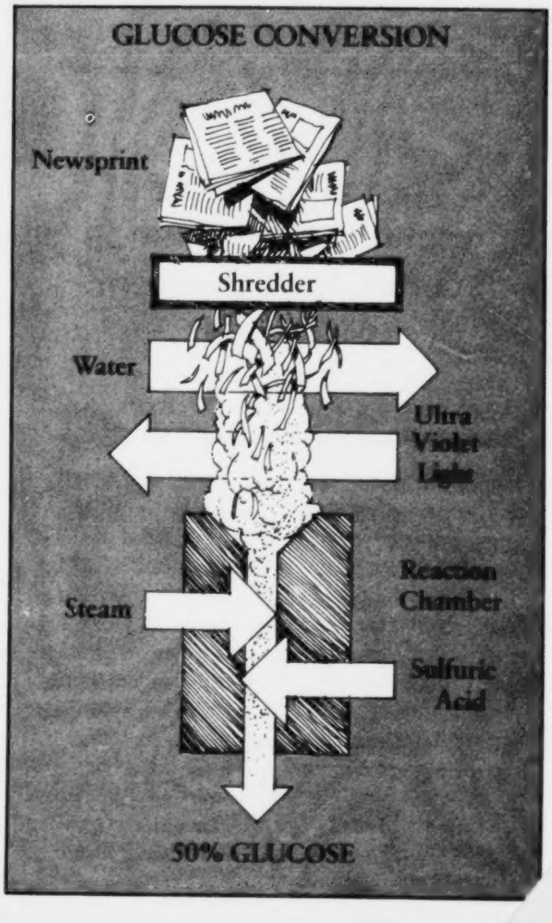
For more than 150 years, scientists have been seeking an economical way to turn wood-based wastes into liquid fuels. EPA's entry into the search for conversion processes has been more recent, beginning in 1975 with a study at New York University (NYU). To date results have been encouraging. By 1979 a pilot plant was in operation capable of converting one ton of newsprint a day into glucose, a sugar which can, in turn, be fermented to produce ethyl alcohol. Ethyl alcohol can then be added to gasoline to produce gasohol, a product now being sold at some gas stations throughout the United States.

Plans are being developed for ten 100-ton/day cellulose-to-glucose pilot plants

To convert the newsprint the ORD-NYU plant makes use of an acid hydrolysis process, which involves exposing shredded, water-soaked newsprint to doses of ultraviolet light. Following this pretreatment, the newsprint is then fed into a reaction chamber where it is exposed to injections of steam and sulfuric acid under moderately high temperature and pressure to yield glucose. Operations at the plant feature an around-the-clock processing technology developed by EPA and NYU. Currently the facility is capable of converting 50% of the available waste into fermentable sugar, with experiments underway to maximize these glucose yields. Plans are also being developed for ten 50-100-ton/day cellulose-glucose pilot plants.

The major question remaining to be answered is whether such a process (or any of the other processes that create ethyl alcohol) can yield a product competitive with the costs of gasoline. As of now, neither the natural processes of fermentation nor the synthetic production of ethyl alcohol using ethylene are able to compete. Ethylene yields ethyl-alcohol at a cost of approximately $1.00 a gallon, 60¢ for the ethylene and 40¢ for the process. Corn converted to ethanol can be produced at $1.56 per gallon. With the conversion cost of glucose to ethyl alcohol pegged at 40¢ per gallon and the cost of the EPA-NYU acid hydrolysis process of waste estimated to range between 45¢ and 60¢, depending on conversion efficiency, the per gallon cost at the gas pump again approaches the $1.00 level.

The EPA process promises the ability to use waste instead of foreign oil for the production of fuel



Old newspapers can be converted into glucose which is an important ingredient of gasohol

These figures demonstrate that due to production costs, farmers are not currently able to produce ethyl alcohol from grain that is competitive with the present cost of gasoline, nor can synthetic production compete unless there is a reduction in the costs of the raw material. The ORD-NYU wastes-to-alcohol process finds itself in a similar situation.

What the EPA process does promise, however, is the ability to use waste instead of foreign oil for the production of fuel and the extension of gas into gasohol. With the possibility of increased oil prices in the future, it is a process that looks more promising each day.

Synthetic Fuel Symposium

In April 1979, EPA held the fourth Symposium on Environmental Aspects of Fuel Conversion Technology. Government agencies, contractors, process developers, manufacturers, university research teams, and private corporations were represented among the over 300 attendees to the meeting, indicating renewed interest in the development of these synthetic fuel conversion technologies.

The first session of the symposium provided a general overview of environmental assessments as well as specific assessment programs. Emerging from the session were two key messages: despite many ongoing projects, much work still remains to eliminate process and pollution control uncertainties; and more cooperation and communication is necessary among sponsoring groups to maximize efficient use of resources.

The major emphasis of the second session was on data and conclusions from ongoing research and field studies. Highlighting this session was a dual presentation by the Yugoslav-U.S. team involved in the environmental assessment of the commercial-scale Lurgi gasifier facility at the Kosovo industrial complex in Yugoslavia.

The third session featured evaluation of environmental control technologies for synthetic fuel plants. Topics included control assay screening procedures, wastewater treatability, and control technology for particulate and tar emissions from coal converters. Other presentations described a gas cleaning pilot plant, and the leaching and chemical analysis of solid wastes.

More cooperation and communication is necessary to maximize efficient use of resources

The third session also saw presentation of a report on water requirements for a variety of synthetic fuel technologies. It was noted that many major coal and oil-shale-bearing regions in the United States would not be able to satisfy the water requirements necessary for synthetic fuel production, due both to limited water supplies and/or human water demand.

Overall, the meeting indicated that substantial progress has been made in determining the environmental effects of synfuel production, and that by the time synthetic fuel plants are operating in this country, the control and monitoring tools and regulations will be available to assure their environmentally acceptable operation.

The following ORD components contributed to the research described above:

- Office of Environmental Engineering and Technology, Industrial Environmental Research Laboratories, Cincinnati and Research Triangle Park—Municipal Environmental Research Laboratory, Cincinnati
- Office of Environmental Processes and Effects Research, Environmental Research Laboratory, Duluth
- Office of Monitoring and Technical Support, Environmental Monitoring Systems Laboratory, Las Vegas

ACID RAIN

The causes and effects of acid precipitation are the focus of ORD research programs

Rainwater, or any other form of precipitation, falling through an atmosphere containing nitrous oxides (NO_x) or sulfur oxides (SO_x) reacts with these pollutants to form acids. The resulting acid precipitation poses a very real threat to sensitive aquatic and terrestrial ecosystems in parts of the U.S. The past few decades have seen a marked trend toward more acid rain. Both the intensity of this acidity and the area affected by it have increased.

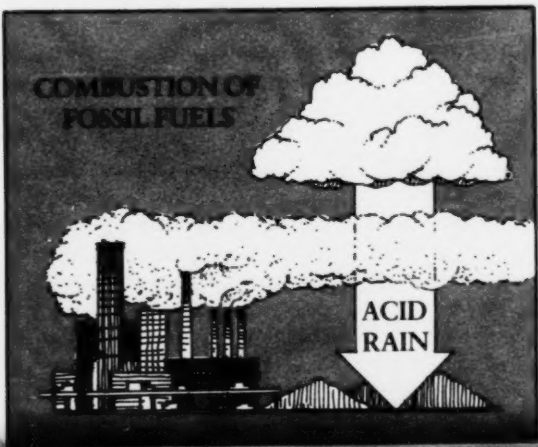
Sulfur oxides are primarily emitted from stationary sources such as utility and industrial boilers burning coal as a fuel. However, nitrogen oxides are emitted from both stationary and transportation-related sources such as cars and trucks. Approximately 56% of the NO_x discharged into the atmosphere in 1977 resulted from the combustion of fossil fuels by stationary sources, while 40% originated from transportation-related sources. Over the next twenty years the combustion of fossil fuels is expected to increase significantly. In particular, emissions of nitrogen oxides from stationary sources are likely to increase rapidly during this period. Precisely what this precipitation means to the environment is the subject of ongoing EPA study.

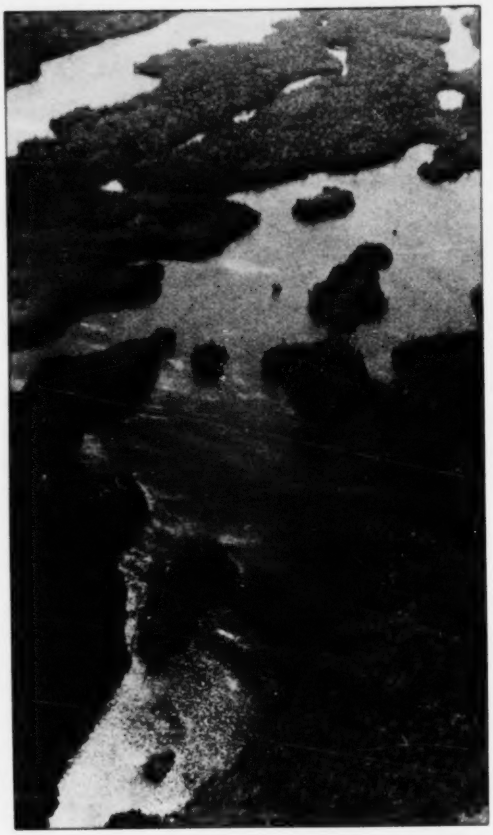
Aquatic Impacts

The air, water, and soil normally possess a buffering capacity that neutralizes acids. As acids are neutralized, this buffering capacity is diminished by a finite amount. This phenomenon is not considered a problem in areas rich in buffering materials, but is a threat to those areas with thin soils and bedrock low in lime or calcite. Here, even relatively small amounts of acid precipitation could exhaust a region's existing buffering capacities and result in the acidification of local ecosystems.

> The most profound damage is to aquatic ecosystems

When the buffering materials in a watershed are depleted, surface waters acidify, and dramatic changes occur. Nutrient concentrations and primary production are reduced. The planktonic and benthic communities are changed to different species with fewer total species and numbers represented. Nutrients are no longer cycled from organic matter, which decomposes more slowly and accumulates in lake basins. Fish fail to reproduce due to the added stress. Those populations of fish reproducing may contain elevated levels of heavy metals. Macrophyte communities are altered with the appearance and proliferation of tolerant species. Such changes have all been documented in lakes affected by acid precipitation. Ultimately, these affected lakes become devoid of useful or desirable forms of aquatic life.

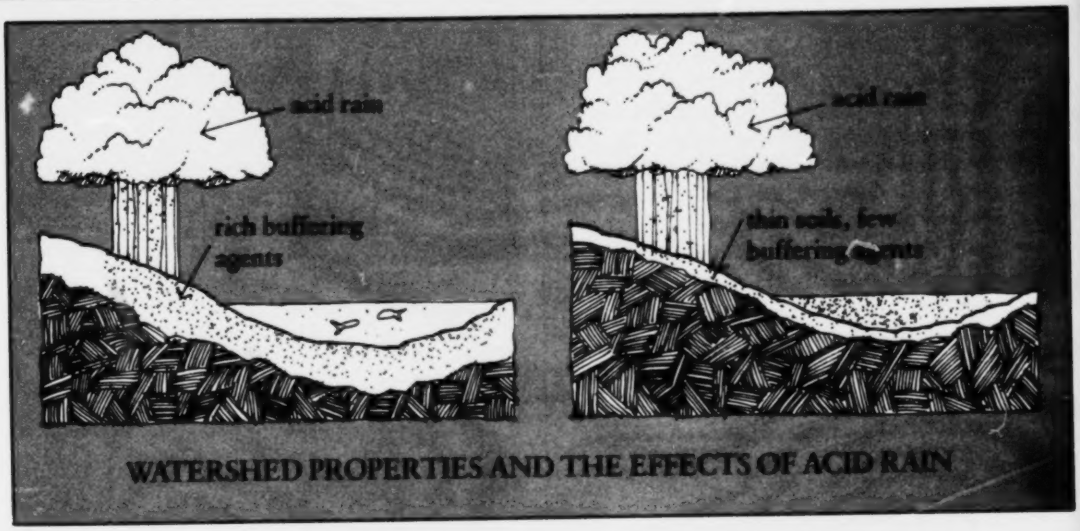




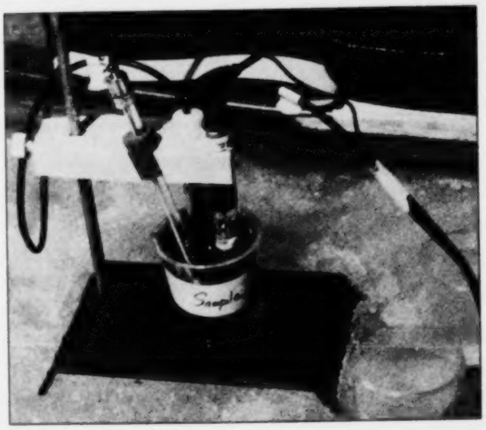
Gaskin Lake in Minnesota's Boundary Waters Canoe Area Wilderness

Because of the severity of the effects on aquatic communities and because the constituents of acid precipitation can be transported hundreds of miles from their source and cause problems in distant susceptible areas, ORD initiated a series of studies of selected northern Minnesota lakes to determine their potential for susceptibility to acid precipitation. Using helicopters and U.S. Forest Service aircraft, more than 100 lakes were surveyed during the fall of 1978 and the spring of 1979. Since acid precipitation accumulates during the winter when it is temporarily stored in the snowpack, periodic snow and meltwater sampling was conducted across the area to determine the largest acid load contributed during snowmelt.

Results of the Minnesota study indicated that many of the lakes were low in buffering materials and would be susceptible to acidification if atmospheric acid loads increased. Preliminary data revealed that atmospheric loading was at or near the critical level, and that any increase in the acid loading could result in the environmental stress of the lakes. Results of the study of the snowmelt indicated that both the buffering capacity and the pH of the receiving waters temporarily decreased (that is, became *more* acidic) during the first part of the snowmelt when the majority of the winter's accumulated contaminants left the snowpack and entered the surface water.



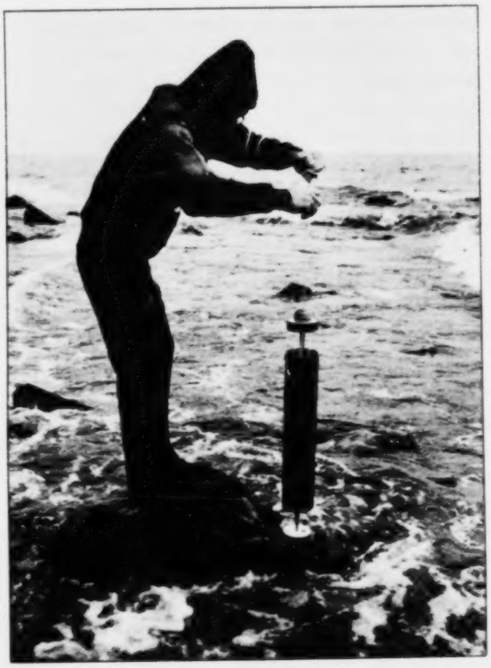
WATERSHED PROPERTIES AND THE EFFECTS OF ACID RAIN



Electrochemical field instruments for measuring pH, oxidation reduction potential, conductivity and temperature

A second ORD study in conjunction with the Wisconsin Department of Natural Resources that samples 400 northern Wisconsin lakes revealed 15% of these lakes to be of lower pH and to have less buffering material than the Minnesota lakes, with some well below the pH level at which biological effects would be expected. Other lakes in both states, it was found, have enough buffering capacity to eliminate them from concern for acidification at this time.

Current research in the impacts of acid precipitation on lakes involves the identification and measurement of parameters that could, in turn, determine the amount of acid loading a given watershed could sustain without undue environmental harm.



Terrestrial Impacts

The impacts of acid precipitation on terrestrial ecosystems represents a major area of interest for EPA researchers. A recent study, partially completed, measured the effects of acid precipitation on 32 major crops that represented a total U.S. annual income of $50 billion. This study was performed in an EPA experimental facility in which the crops were grown under controlled environmental conditions and exposed to simulated sulfuric acid rain of: pH 3.0, 3.5 and 4.0, in addition to a control rain of pH 5.7. Injury to foliage and effects on yield of edible portions was then determined.

Initial results of this study indicated that some crops suffered severe damage, but others sustained little apparent injury. For example, the leafy portion of mustard greens and the edible portion of broccoli exposed to rain of pH 3.0 were reduced in weight by an average of 30% and 25%, respectively, when compared to controls. The edible portion of radishes exposed to pH 3.0

weighed *less than half* that of radishes receiving normal rain. Spinach growth was reduced by only 15%, but the leaves were so badly pitted that the spinach was unmarketable.

Bluegrass yield at pH 3.0 was reduced by 30% by weight and clover 21%. Both showed visual damage. Under less acidic conditions (pH 3.5-4.0) the yields of mustard greens, radishes, and bluegrass were still from 14% to 28% less than the corresponding controls. Cauliflower, cabbage, and green peas seemed negligibly affected, indicating a greater tolerance to increased acidity in these plants.

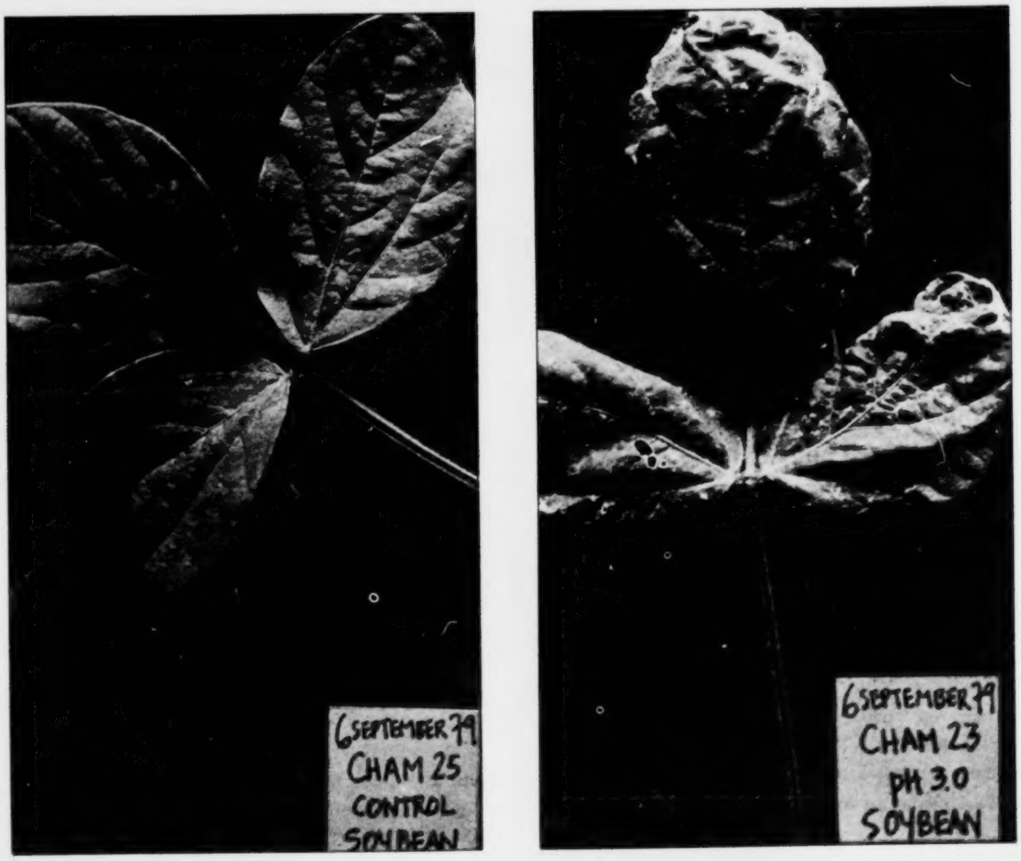
A second study exposed bush beans — demonstrated to be highly acid resistant—to different sulfuric acid and nitric acid mixtures to determine which blend of constituents was not harmful. Results showed no effect on crop yield at pH 3.0 or above. Under more extreme conditions reduction in growth was observed at pH 2.0 in beans exposed to rains both high in sulfuric acid and high in nitric acid. More visible tissue damage resulted from the high sulfuric acid rain.

A third terrestrial impact study examined a number of forest microcosms created to simulate environmental conditions in the northeast where the acid precipitation problem is most severe. Each microcosm, containing sugar maple and alder trees grown in natural soil-litter mixtures, was exposed to artificial acid rain under controlled conditions so that effects on both plant growths and soil nutrients could be studied and trends predicted. When all the results are in, computer models of affected ecosystems will be used in conjunction with other research findings to derive a clearer picture of what lies in the future for northeastern forests. Additionally, recent ORD experiments indicate that acid precipitation can:

- Damage foliage
- Accelerate plant surface erosion
- Alter responses to associated organisms
- Affect germination of conifer and hardwood seeds
- Affect the establishment of seedlings
- Affect the availability of nitrogen from the soil
- Decrease soil respiration
- Increase leaching of nutrients from the soil.

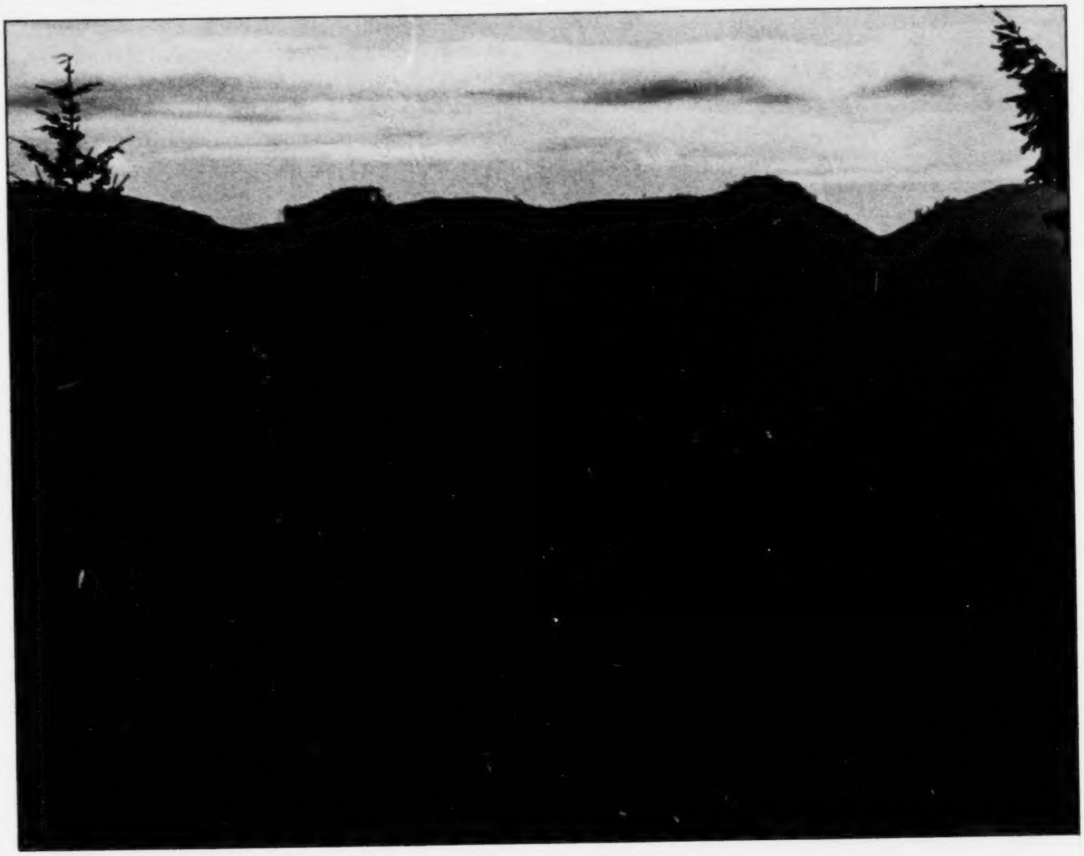
The following ORD components contributed to the research described above:

■ Office of Environmental Processes and Effects Research—Environmental Research Laboratories, Duluth and Corvallis



Lowered pH levels can have drastic effects on plant life

CLEAN AIR MONITORING



A new look at visibility and the use of space age technology facilitates ORD's air quality research

ORD research on the maintenance and improvement of air quality was performed on a broad scale in 1979. Monitoring instruments were developed, evaluated, refined, and utilized. Improved methods of SO_2 emissions control were evolved to facilitate the nation's transition to the burning of high sulfur coal. And space-age technology became part of the clean air effort as ORD made use of solar cells and satellites to keep an environmental eye on remote areas of the country.

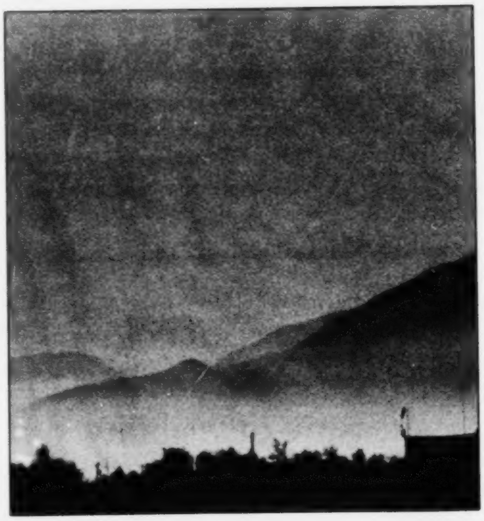
1979 clean air monitoring highlights include:

Optimal Air Quality Monitoring

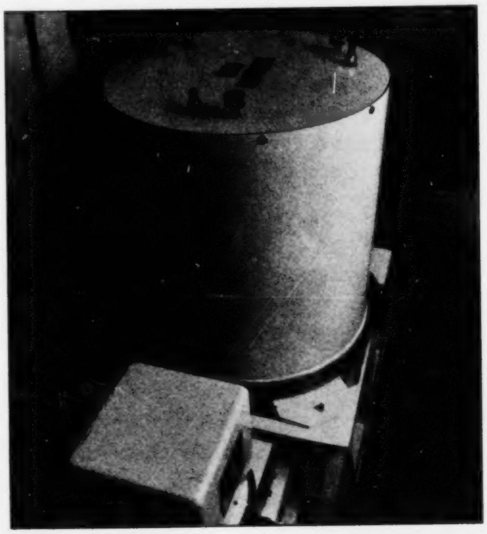
The Clean Air Act requires state and local agencies to monitor ambient air quality, primarily to document an area's compliance to the National Ambient Air Quality Standards (NAAQS). To assist in this monitoring effort, ORD addressed the question of whether it was possible to develop and validate a method of determining the precise location and number of sampling stations necessary to monitor ambient air quality — was there, in other words, a way of setting up an optimal air quality monitoring network in a given area?

One such method was defined in the 1979 EPA research program and involves the use of an air quality simulation computer model to develop a data base for the region under consideration. Meteorological information is fed into the model to replicate all of the important weather scenarios for that region. Existing pollutant emission information is then added to the model as an overlay to the scenarios. A series of pollutant maps can then be generated for the area, which locate the coordinates of pollutant concentration peaks. Simplified, these data can then be used to provide the relative frequencies of the pollutant's occurrence over a broad range of weather conditions. With this information in hand monitoring stations can then be located and ranked based either on their expected exposure to occasions when NAAQS standards are exceeded or their expected ability to represent a region's overall air quality. Based on those criteria, this method also includes a procedure to objectively limit the number of stations to a required minimum.

This initial application of the method was for an inert pollutant, carbon monoxide (CO), in the Las Vegas valley. To validate this model, a key element in its development, a limited but intensive field sampling program was undertaken. In this study it was hoped that a high correlation between the model-predicted incidence and location of CO and the measured incidence and location of CO would be demonstrated. Such a correlation would indicate that the modeling method was effective in defining both peaks of CO concentrations as well as the locations of those peaks. The results of the validation showed a high degree of agreement between predicted and measured values of CO for nearly all cases examined. Currently, network selections are being evaluated, with verification studies for other pollutants and for other locales also underway.



Work is also in progress on a radically different method of determining the number and location of monitoring stations. The monitoring network in this ORD study is based on a region's wind field patterns rather than directly on air pollution distribution. It is thought that, by concentrating on wind field a more stable, long-term monitoring network might be established, one less directly influenced by changes in pollutant emission source locations and emission values. Three separate models are used in this method. The first simulates wind field; the second determines the wind monitoring network using the simulated wind data; and the third establishes pollutant concentration distribution by making use of wind data and existing emission and pollutant concentration data. Results from evaluation and validation studies of this wind field method will soon be forthcoming.



Lidar unit installed in an aircraft

Atmospheric Particulates

Since 1973, EPA has been working with an airborne remote sensing device called lidar to map particulate matter in the atmosphere. Lidar (light detection and ranging) probes the atmosphere beneath an aircraft in the same way a depth sounder probes water beneath a boat. A light pulse is emitted by a laser pointed toward the earth. As the pulse travels through the atmosphere striking air molecules and aerosols, light is scattered back to the aircraft's onboard sensing and recording devices. Measurements taken from this scattered light can then be used along with navigational information to indicate pollutant plume dimensions and locations.

In 1979, a third generation lidar system was developed and flight-tested to enhance EPA's monitoring capabilities. As with first and second generation systems, this lidar is capable of the three-dimensional characterization of airborne particulate plumes. This third system, however, is also capable of performing some characterization of the particles themselves. This in-air analysis is made possible by the addition of a second lidar frequency: the first to characterize the plume location, the second the approximate size of the particles based on their ability to scatter light.

Other features of the third generation system involve laser firing-time intervals and data output capabilities. The first generation lidar could only be fired once every 12 seconds; the two-frequency system can be fired ten times every second, thus greatly increasing the system's ability to define plume dimensions. Data from the first generation device had to be extensively manipulated using a ground-based digital computer, with output often delayed for several months. The two-frequency lidar uses two microprocessor computer systems built into the device, which give instant access to data, even as they control and monitor system functions.

The two-frequency lidar, to be in full use by 1980, will provide EPA air quality investigations with yet higher quality and more comprehensive data for its enforcement of the Clean Air Act Amendments.

The broad white band across the bottom of this display is a plume as seen by Lidar

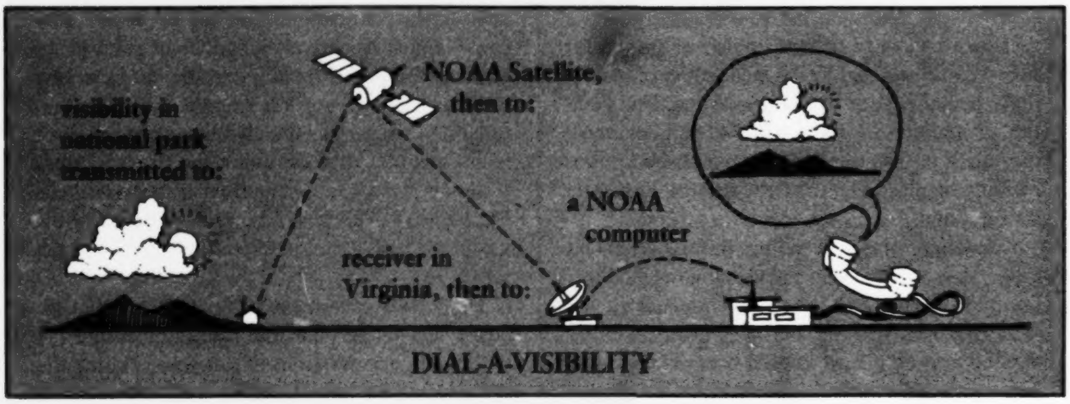
What Is Visibility

What is visibility? Is it merely "as far as the eye can see"? Can it be quantified? In 1979, researchers on ORD's Visibility Investigative Experiment in the West (VIEW) worked to provide answers to these questions and others. Initially a program to establish visibility baseline data for the Western Energy Research Development Area, VIEW objectives were expanded as a result of the visibility protection mandate established by Congress. Now VIEW seeks to:

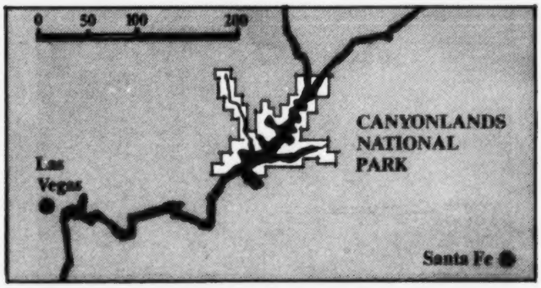
- Establish an instrument(s) that characterizes visibility
- Develop a western regional visibility data base
- Identify air pollutant emission sources responsible for visibility degradation

To fulfill the first objective ORD initiated a research program at Canyonlands National Park to investigate the tools of the visibility measurement trade. Of the numerous devices tested, none was demonstrated capable of independently establishing the relationship of air pollution to visibility. While, for example, long-path telephotometer measurements most closely represented that quality of a given vista observed by the human eye, under certain meteorological conditions it was difficult to relate these measurements to degraded air quality. And while an integrating nephelometer proved to be effective in measuring air quality under all meteorological conditions, the device was constrained to making point measurements which are highly dependent on local sources. It was thus expected that characterizing visibility would involve a number of instruments in combination.

The degree of color contrast was the key measure of visibility



A survey was then taken to establish the relationship between what the instruments measured and what the human eye actually perceived. Visitors to Canyonlands participated in the survey. Analysis of the data gathered from the subjects' viewing of slides and specific vistas established that the degree of color contrast was a key measure of visibility. Also developed from the data was a method to quantify the effect that weather and scenic beauty have on a person's ability to perceive degraded air quality.



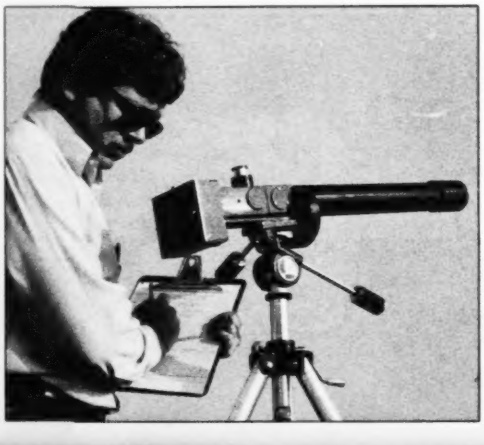
Work on VIEW's second objective involved area-wide monitoring to create a western visibility data base. In a graphic illustration of the adage that "looks deceive," it was established from these monitoring data that air quality in a number of areas was approximately 50% cleaner than was previously assumed based on airport visibility observations. However, this discrepancy is understandable since airport observations are not necessarily representative of area-wide visibility, and furthermore, visibility in relatively clean air can be degraded by even small, local increases in air pollution.

VIEW's third objective, to identify the sources responsible for visibility degradation, was furthered by the development of a program to monitor particulates. A sampling network was deployed and samples were analyzed. Preliminary results indicated that suspended soil materials and sulfur in the form of sulfates most often interfered with visibility.

Satellites, Solar Cells

For the price of a phone call, ORD will soon be able to summon data on visibility conditions at Lava Point in Zion National Park, Utah. The information ORD will receive will have traveled over 50,000 miles in a matter of seconds and will not have necessitated the lifting of a single human finger beyond the one that dialed the phone.

When Congress mandated visibility protection in national parks and wilderness areas, ORD responded by adapting space-age technology to enable the monitoring and transmission of visibility data from these often remote locations. Instruments powered by solar cells collect the data, which are then beamed to the western Geostationary Operational Environmental Satellite controlled by the National Oceanic and Atmospheric Administration (NOAA). The data are relayed from the satellite to a receiver in Virginia, then to NOAA's computer in Camp Springs, Maryland. A phone call to this NOAA installation then yields this Lava Point visibility information. The Zion National Park system is now ready for use and will become operational following clearance from the Interdepartmental Radio Advisory Committee.



The Contrast Telephotometer measures visibility

A current limitation inherent in the system is that data can only be transmitted at prescribed times, as determined by the availability of receiving and transmission equipment on board the satellite. In addition, as the number of stations transmitting to the satellite grows, restrictions will inevitably be placed on the frequency of single site transmissions.

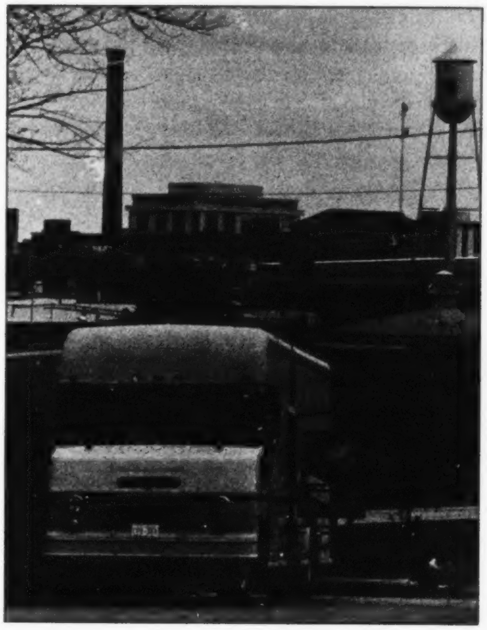
Limitations notwithstanding, it is expected that this system will usher in a new era in the monitoring of isolated locations. If performance of the system proves reliable and satisfactory, similar systems may be placed in other national parks and wilderness areas, enabling EPA to monitor the visibility and receive near-instant information from an entire network of remote locations.

Remote Optical Sensing

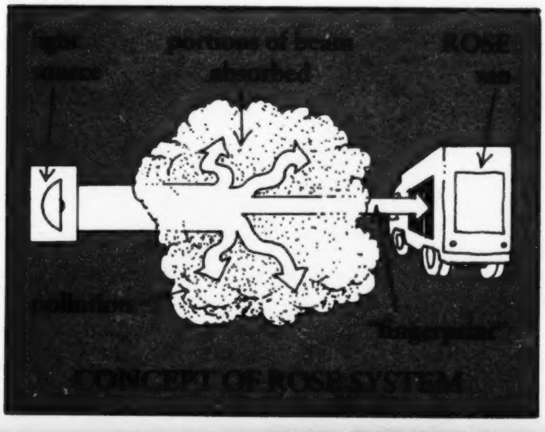
In addition to the airborne lidar three other remote optical sensing systems are in use by ORD today—the ROSE infrared system to measure atmospheric gas concentrations, a ground-based lidar system to measure airborne particle concentrations, and the mobile laser-Doppler velocimeter (LDV) system to measure the rate of movement of the gases and particles. These instruments, which are capable of measuring air pollution without the necessity of collecting physical samples, are used to characterize emissions from all types of mobile and stationary sources. Of further value to EPA is the instruments' ability to make pollution measurements at almost any time without the knowledge of suspected polluters.

The ROSE (Remote Optical Sensing of Emissions) system consists of special telescopes, an infrared spectrometer and a computer, all located in an EPA van. In operation, an infrared light source sends a beam through the atmosphere to be captured by the telescope in the van, the telescope then focuses the beam onto the spectrometer for analysis in conjunction with the computer. Because almost all natural and pollutant gases in the air absorb infrared light at specific characteristic frequencies, each gas has its own infrared signature or "fingerprint" which thus permits positive identification by the computer/spectrometer analysis. Once the gas is identified, further analysis can be used to compute the actual amount of the gas in the path between the infrared light and the telescope.

The ROSE system can be pointed at a specific target such as an industrial stack to measure the types and concentrations of hot gases exiting the stack. For such targets, the system's maximum range is approximately one kilometer. For general atmospheric measurements, ROSE has a range of several kilometers.



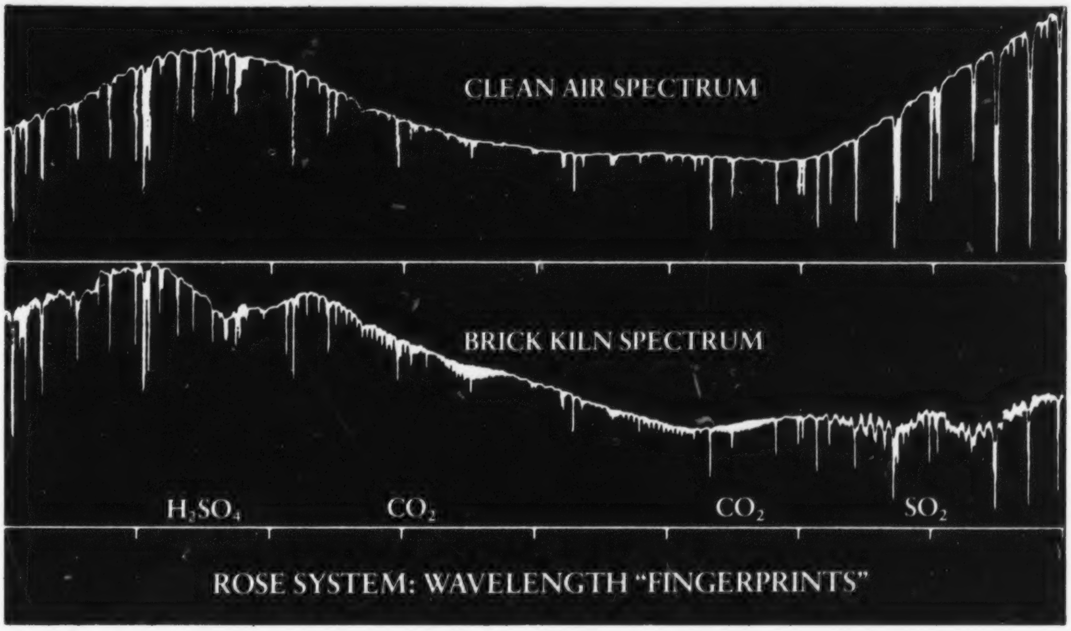
The ROSE system in action



In 1979 the ROSE system:

- Identified and quantified gaseous pollutants emitted by kilns used in the manufacture of bricks.
- Analyzed hot exhaust gases from jet engines at Tyndall Air Force Base.
- Verified hydrogen fluoride as the only significant gaseous fluoride emitted from phosphate fertilizer plant wastewater treatment ponds.
- Demonstrated its ability to quantify hot gas emissions from waste gas flares, a widely used emission control technique that generally defies conventional analysis techniques.

The ground-based lidar system for particulate concentration measurements also was used extensively during the 1979 ORD research year. It operates on the same physical principles as the airborne lidar.



ROSE SYSTEM: WAVELENGTH "FINGERPRINTS"

In recent studies, measurements of opacity taken by the ground-based lidar were compared with those made by trained observers and in-stack measuring devices. The data from the measurement studies helped determine the relationship between opacity and mass particulate concentrations. 1979 also saw modernization of the system with the addition of a new laser, data processing system, and van.

Current lidar work includes studies of coal-fired power plant emissions at five generating stations, development of a low-cost lidar system, and development of a system for the remote determination of particulate size distributions in stack emissions.

The third remote optical sensing system, the mobile LDV system, was delivered to ORD this year. NASA scientists who have been actively developing LDV systems for 10 years assisted EPA in the development of the current LDV system. This system is used to measure wind or stack plume velocities by sending a CO_2 laser beam into the atmosphere or a stack plume. Part of the beam is backscattered as it comes into contact with aerosols. Because of the velocity of the aerosols, the frequency of the backscattered beam shifts as a result of the phenomenon known as the Doppler effect. This backscattered beam frequency is then compared by computer with the outgoing beam frequency, and the resulting difference allows for the remote computation of the aerosols' velocity. The measurement of wind velocity at different plume altitudes is more complex than measuring the plume velocity but it is based on the same principle.

These devices are capable of measuring air pollution without collecting physical samples

A Lidar van measuring industrial emissions

The velocity data then can be used in conjunction with pollutant concentration data gathered by the other remote sensors to calculate total area-wide pollution concentrations from both point sources and extended area sources. This methodology is particularly suited for the difficult task of quantifying the net amount of pollutants in the air from fugitive emission sources.

All three systems will continue to be evaluated, improved, and used in 1980 ORD research work.

Atmospheric Sulfates Analysis

Sulfate emissions can consist of gas or aerosol sulfuric acid and sulfate salts such as $MgSO_4$, $VOSO_4$, and Na_2SO_4. These air pollutants come mainly from coal- and oil-fired power plants, pulp and paper mills, cement kilns and a variety of similar industrial sources, and can contribute to the causes of acid rain, poor visibility, and human health problems. Furthermore, increasing evidence points to oil-fired power plants as the major contributor to the high levels of sulfates measured in the northeast United States.

EPA's responsibility to keep the air clean of these damaging pollutants requires formulation and recommendation of strategies to control the pollutants, but two likely targets for the EPA control strategies—type of fuel and type of combustion—also appear to directly influence the extent of sulfuric acid production and hence the amount of atmospheric acid. Therefore, to formulate the appropriate controls, EPA needs to know the relative amounts of air pollution in the form of sulfuric acid as compared to the total sulfate load. To accomplish this differentiation of acid from the sulfate salts, ORD research has developed two methods to continuously monitor sulfuric acid in the hot gases which come from smoke stacks.

The first method is an automated procedure which first filters particles from the stack gases and then condenses out the sulfuric acid. Measurements by this method have shown that most of the sulfuric acid is emitted as a gas, not as a particle or an aerosol. This monitoring and analysis method has been used on oil-fired boilers to determine how much acid can escape from flue gas desulfurization control devices.

The second ORD monitoring method uses a diode laser pointed at the stack gases. By employing known optical absorption and light scattering characteristics of sulfuric acid, the laser device can produce real-time measurement of acid emissions. In one test, combustion changes in an oil-fired boiler showed up immediately by changes in sulfuric acid emission.

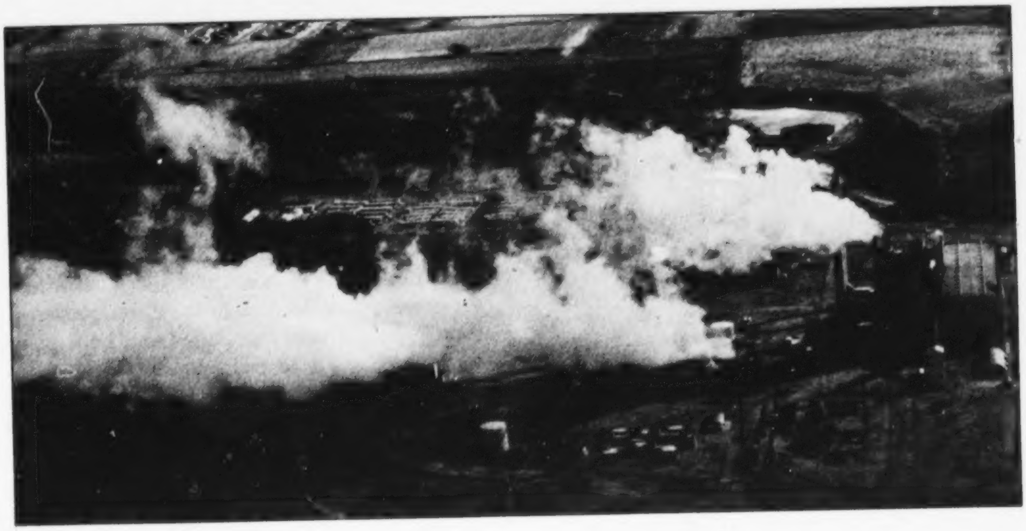
In related work, ORD scientists identified problems with handling aerosol samples that were to be analyzed for acidity. For example, samples collected in the field, in particular in rural areas, were occasionally contaminated with coarse alkaline particles, and samples transported or stored were sometimes exposed to ammonia gas. The alkaline particles and ammonia gas neutralized the aerosol acids thus leading to incorrect acidity readings when the samples were analyzed. Further problems included sample contamination from previously-used glass fiber filters.

> Preliminary results indicated that sulfates and suspended soil most often interfered with visibility

To solve these problems Teflon filters replaced the glass filters, dichotomous samplers were used to keep the alkaline particles separate from the aerosols and better storage and handling techniques were instituted. Establishment of these procedures enabled ORD scientists to make much more accurate measurements of sulfates in aerosol samples taken in rural areas.

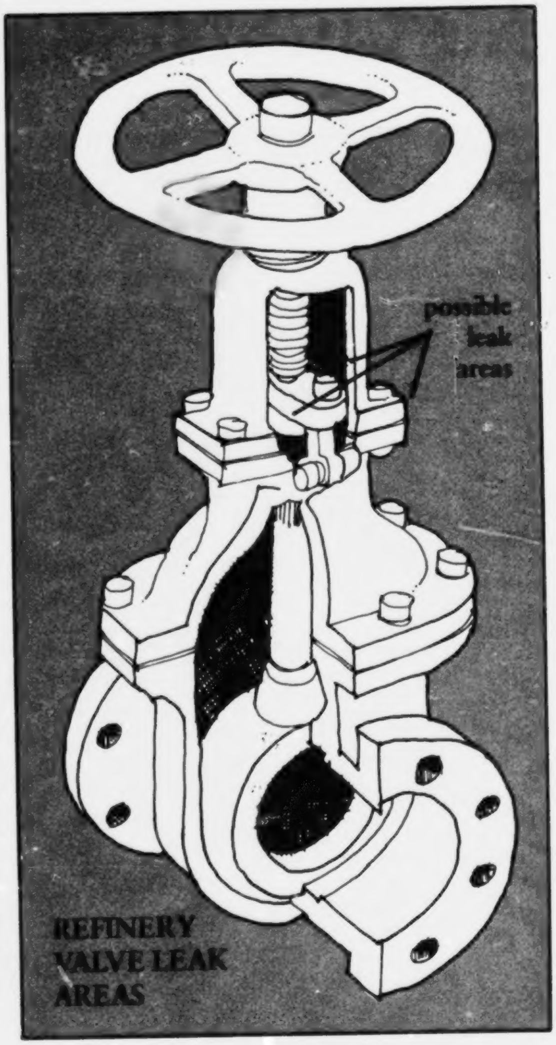
ORD scientists solved another acids analysis problem in 1979. In the past, air samples taken to a laboratory and used for acidity analysis could be used for no other analyses because of the risk of acid neutralization by ammonia in the laboratory

Stack gasses from coal-fired power plant



air. This meant that field sampling personnel had to collect numerous samples for the many analytical tests performed by EPA. ORD solved the problem by inventing a new acidity analysis method consisting of titration of the samples with carbon-14 labeled trimethylamine. The samples analyzed by the new method remain sufficiently unaltered so subsequent tests can be performed accurately and efficiently.

All of these new monitoring and analysis techniques will help make EPA clean air monitoring tasks more accurate and more cost-effective.



Fugitive Emissions

The average leaky valve in a petroleum refinery emits only about a half a pound of hydrocarbon vapor into the air per day. This single fugitive emission source of Volatile Organic Compounds (VOC) is hardly significant by itself, but when taken along with the thousands of other potential sources of fugitive emissions in a refinery — spills, open drains, leaky components, wastewater treatment streams — the deterioration of air quality and the hazard to human health can be significant.

A 1979 ORD study of fugitive emissions at fourteen oil refineries examined the problem and determined steps that could be taken to alleviate it. Thousands of potential sources of fugitive emissions were investigated using a portable hydrocarbon detector. Those sources found to emit hydrocarbons were then studied to determine their actual leak rate. This was done by enclosing the leaking source in a plastic enclosure and measuring VOC emissions over a fixed period of time. To determine the effectiveness of maintenance in reducing emissions, a number of the leaking sources were repaired by refinery maintenance personnel, then resampled to determine any decreases in emissions rates.

Thousands of potential sources of fugitive emissions were investigated

Of note, this research effort yielded the average leak rate of fugitive VOC emission sources in petroleum refineries, the first substantive data gathered on this topic in twenty years. Data on the frequency of leak occurrence were also obtained, as well as data on the effectiveness of maintenance in the reduction of fugitive emissions. In addition, the research pointed to the need for future efforts to better quantify emissions from petrochemical process units and to reduce emissions from refinery wastewater systems.

As a result of this study, EPA now has the data necessary to set effective regulations to control the sources of fugitive VOC emissions in petroleum refineries.

The following ORD components contributed to the research described above:

- Office of Environmental Engineering and Technology—Industrial Environmental Research Laboratories-Cincinnati and Research Triangle Park
- Office of Monitoring and Technical Support—Environmental Monitoring Systems Laboratory, Las Vegas
- Office of Environmental Processes and Effects Research—Environmental Sciences Research Laboratory, Research Triangle Park

NON-IONIZING RADIATION

Radio and television transmitting tower

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ORD researches the possible health hazards of electronic smog

Radiation is a form of energy emitted as waves or particles. When the radiation is of high energy, as from nuclear radiation, it ionizes material; that is, it separates electrons from atoms or molecules. Such ionizing radiation is known to be lethal. By contrast, non-ionizing radiation (NIR) is far less energetic, and is of longer wavelength. Its sources are hardly exotic and are, in fact, part of our everyday lives and include radios, televisions, electric power lines, microwave ovens, citizen band radios, and air traffic control radars.

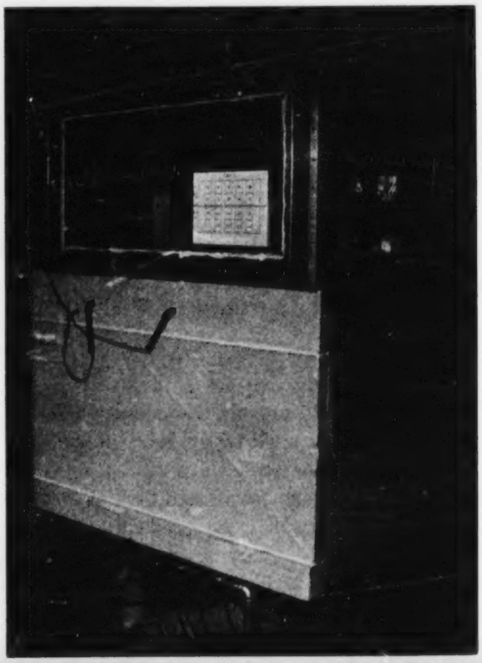
Sometimes characterized as "electronic smog," levels of NIR have grown with the proliferation of electronic devices and their applications. As the number of these sources increases, the U.S. population is faced with increasing exposure to low-level radio and microwave frequency radiation. Little, however, is known about possible health effects that may result from these exposures, and public attention to the problem has only recently been piqued by news reports of the beaming of microwave radiation at the U.S. embassy in

Moscow. Currently, a number of interdisciplinary studies by ORD are underway to examine the possible risks posed by low-level exposures.

One study, completed in 1979, examined pregnant rats and their offspring exposed to a radio frequency of 100 MHz to determine whether such exposure might impair growth, neurological development, behavior, and reproductive capacity. In addition, factors relative to neurochemistry, mutagenicity, hematology, and immunology were also examined. The 100 MHz frequency is part of the FM radio frequency band and falls in the range that contributes most to ambient radio frequency radiation. It is also close to the frequencies at which maximum absorption of energy occurs in human tissue (i.e., 70-80 MHz).

Non-ionizing radiation is part of our everyday lives

Rats in this study were exposed at power density levels over 50,000 times higher than the levels experienced by the general public from radio transmitting stations, but because of body size differences, the rate of energy absorption in the rats was equivalent to that experienced by humans exposed to the occupational guidelines. Exposure was for four hours daily throughout pregnancy; the offspring were similarly exposed until they were young adults at 90 days of age.

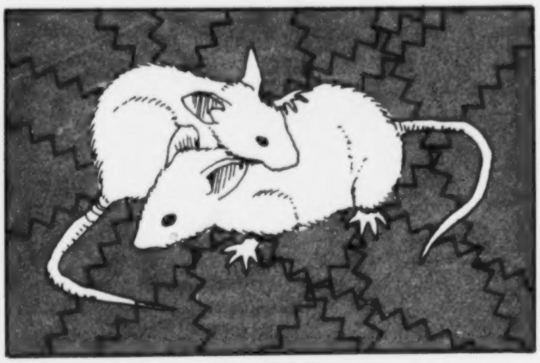


Non-Ionizing test unit

DANGER
HIGH VOLTAGE

Laboratory rat being exposed to radio frequency of 100 MHz

The results of this study showed that no overall change in the growth and neurological development of offspring was evident at these power density levels. Also, examination of the rats' immune systems and blood failed to show any alterations that might lead to disease.



Male offspring suffered no impairment to reproductive capacity. The behavior of the animals did not appear to be altered. In some of the rats, however, levels of a brain enzyme were altered. The reasons for the enzymatic change, as well as its consequence to the health of rats, still needs to be determined.

Additional data on the health effects of other NIR frequencies of environmental significance are currently being generated in other ORD studies along with information on how NIR interacts with biological systems. These data will be important to the development of federal guidance on NIR in the environment.

The following ORD components contributed to the research described above:

- Office of Health Research—Health Effects Research Laboratory, Research Triangle Park

TOXICS

Chemical samples during testing for toxicity

Researchers seek those chemicals with the potential for environmental and human harm

Any chemical can be toxic at the right dose and under the right circumstances. But what is that dose? That circumstance? And what precisely is the mechanism that brings about its toxicity? ORD is attempting to understand the behavior of chemicals and their effects on the environment and on humans, and to establish scientifically sound techniques to both estimate and control the risks they pose. The following are highlights of the 1979 research effort.

Chlorinated Dioxins

Chlorinated dioxins are a family of highly toxic, related organic compounds generally occurring as unwanted by-products in the manufacture of certain chemicals (e.g., 2,4,5, trichlorophenal). One such chlorinated dioxin, 2,3,7,8-TCDD, has been called the most toxic molecule synthesized by man. Extremely small amounts can cause skin, liver, and kidney disorders, birth defects, and possibly cancer. While modifications in industrial processes have reduced the quantity of chlorinated dioxins produced, methods for the disposal of the remaining chlorinated dioxins in industrial wastes are not clearly defined.

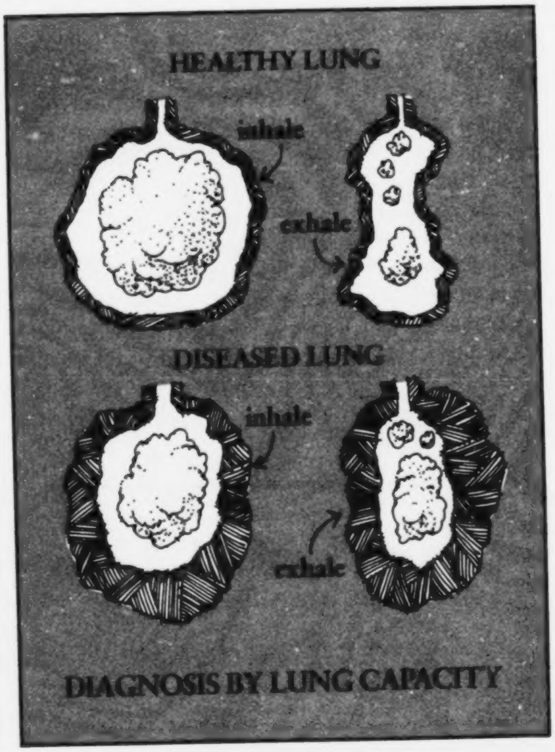
In 1979 ORD research in this area focused on the development of effective chlorinated dioxin detection methods, highlighted by the development of an analytical procedure for detecting parts per trillion (ppt) levels of chlorinated dioxins in complex industrial wastes. The key to the process was a sample clean-up procedure that could separate the chlorinated dioxins from the complex background of waste materials, and then make use of a known amount of "labeled" TCDD as a standard of measurement.

TCDD has been called the most toxic molecule synthesized by man

A second result of the ORD chlorinated dioxin detection effort was the discovery of environmental contamination by TCDD in Arkansas. The discovery came about after 17 samples, which were collected in the vicinity of a chemical manufacturing plant, had been analyzed and some found to contain dioxin. The initial ORD analysis of 40 ppm TCDD was subsequently confirmed by an independent laboratory.

Subsequently, the discovery led to the notification of Region VI personnel by ORD. Continued investigations have shown TCDD to be present in the local sewage treatment system used by the plant and at low levels in surface waters and fish downstream from the pollution source. Contaminated waterways have been quarantined and a comprehensive health evaluation of present and former employees is now underway. Additionally, the plant has ceased production of the trichlorophenol and 2,4,5-T that created the hazard.

In other dioxin-related activities, ORD provided technical assistance to the Australian government in the disposition of dioxin wastes trapped in activated carbon and took part in EPA's review of a chemical company's data concerning the discovery of TCDD in fish downstream of the company's Michigan facility. In addition, ORD participated in the EPA's dioxin task force, whose primary function is to coordinate the agency-wide chlorinated dioxin program.

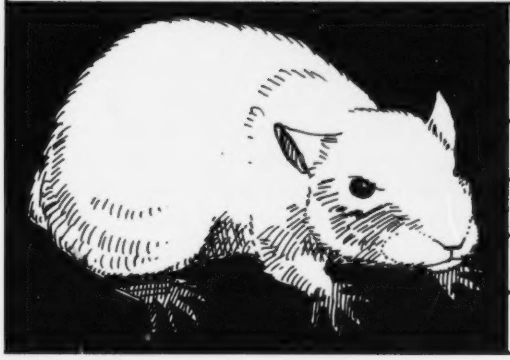


Pulmonary Function

1979 saw the development of a series of tests of pulmonary function that can be applied to small laboratory animals exposed to pollutants. These tests can provide information on functional changes in the lungs of test animals, which, in turn, may indicate the development of chronic pulmonary disease. A number of tests were developed capable of a variety of measures.

One such test measures the volume of gas remaining in the lungs after maximal exhalation. This test is valuable in that it helps identify obstructive diseases such as emphysema or

FUNCTIONAL CHANGES IN HAMSTER LUNGS FOLLOWING TREATMENT WITH ELASTASE



	CONTROL	TREATED
BODY WEIGHT (g)	119	118
LUNG WEIGHT (g)	0.60	0.68
LUNG CAPACITY (ml)	5.9	8.7
RESIDUAL VOLUME	1.1	1.8
NO. OF ANIMALS	10	7

chronic bronchitis. When these diseases occur, the total volume of gas the lungs can hold is increased due to a breakdown in lung tissue, while the amount of gas remaining in the lungs after a maximal exhalation is also increased due to obstruction or collapse in the airways.

A second test determines how well the lung is ventilated. This is accomplished by measuring the amount of time it takes the lung to wash out the nitrogen contained in the lungs when an animal is breathing pure oxygen. A lung demonstrating poor ventilation characteristics is often an early sign of respiratory disease.

A poorly ventilated lung is often an early sign of respiratory disease

A third test measures the rate at which a test gas diffuses from the air spaces in the lungs into the blood. This test measuring the lungs' diffusing capacity is useful in determining whether obstructive or tissue diseases are present.

Recent ORD research proved that functional changes in the lungs, as measured by these tests, are indeed consistent with actual lung damage. Hamsters were given emphysema by treating them with the enzyme elastase. Their lung functions were then tested. Results indicated that nitrogen washout was delayed, total lung capacity and residual volume were increased, and the lungs' diffusing capacity was diminished.

In another study making use of the pulmonary function tests, rats were exposed to asbestos fibers for one year and then examined to evaluate the functional status of their lungs. The results indicated a marked reduction in total lung capacity.

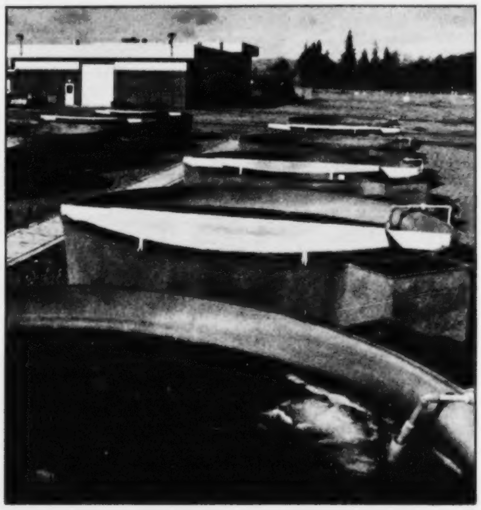
ORD effects data generated making use of these and other pulmonary test techniques on animals will be vital in indicating the potential health hazards of inhaled environmental pollutants.

Aquatic Indicators

A pilot research program investigating the use of aquatic animals as indicators of the presence and the potential effects of toxics in the larger environment is a study approach being taken by ORD in conjunction with the National Cancer Institute. The use of the aquatic community to augment laboratory toxicity studies performed on rats

Possible tumor in clam taken from coastal waters off the northern Gulf of Mexico and mice is based on the premise that water, aquatic biota, and sediments are the ultimate "sinks" for the runoff, fallout, and discharge of most toxic pollutants, and that species living in the water are completely exposed to pollutants, and less able than land species to escape a dissolved or carried toxicant.

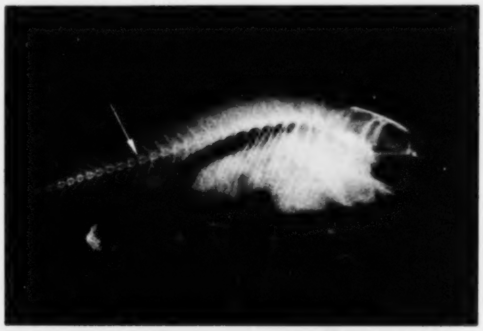
In 1979, researchers studied species of fish and shellfish along the northern Gulf of Mexico to determine which species might be the most effective indicators of carcinogenic agents in the environment. Fish, oyster, and clam populations were analyzed monthly for tumors and cellular diseases indicative of pollution. Additionally, chemical analyses are now being performed in a search for residues of potential carcinogens. Sampling stations were located in both polluted and clean estuaries as well as offshore in relatively pristine waters. Also, as part of the study, select species of fish were exposed in the laboratory to determine their specific responses to chemical carcinogens known to occur in the environment.



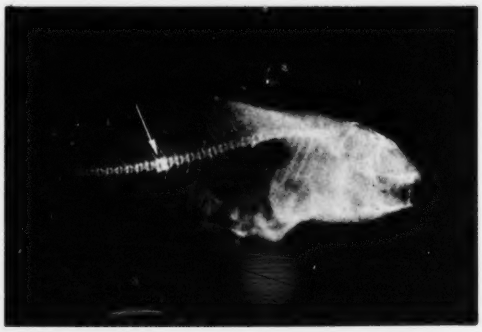
Outdoor aquatic research test tanks

Results of the study to date have generally proven fish to be suitable experimental test animals. Certain species of fish, it was demonstrated, can be kept in the laboratory for long-term (one year and longer) testing of their potential to develop tumors from select chemicals released into the environment. One such species, for example, exposed to the herbicide Trifluralin for ten to twelve months, developed abnormal growths on their vertebral columns.

Field study results demonstrated that some members of fish and shellfish populations in both polluted and apparently clean coastal waters suffered from a variety of tumors and tumor-like lesions. This prompted researchers to attempt to correlate the presence of these tumors with the presence of certain pollutants in the water, in the sediment, and in fish tissues.



Radiograph of normal Sheepshead Minnow



Radiograph of Sheepshead Minnow exposed for eight months to the herbicide Trifluralin

Another finding demonstrated that fish, when exposed to a carcinogen, undergo biochemical changes in tissues, such as the liver, that are similar to the precancerous changes that occur in the livers of mammals when exposed to the same carcinogen. This result further points to the potential value of fish as research animals for carcinogen assay.

In the years to come results from these studies will aid in evaluating the appropriateness of using aquatic communities and other forms of wildlife as indicators of the presence and effects of pollutants. Also, data generated in these studies will aid in determining the routes taken by carcinogens in water and the human health risks posed by this water and the aquatic organisms used as food by man.

Toxicity Test Standardization

To assure that the short-term screening test methods for toxics being developed by ORD ecological effects laboratories were reliable, a round robin system of test method evaluation was initiated in 1979. Participating in the evaluation were four of EPA's research laboratories and several contract laboratories. Variability of animal test results among laboratories is currently being determined so weaknesses or needed improvements can be identified.

The initial products of these standardized toxicity tests will be available in early 1980 and will include results of acute toxicity testing on the mysid shrimp, a copepod, the sheepshead minnow, the fathead minnow, and the rainbow trout.

Additional test method development and standardization will continue through 1980 and beyond. Among the items on the research agenda are chronic toxicity tests with marine and freshwater plankton, marine and freshwater fishes, shellfish, and other organisms. Tests for the bioaccumulation of chemicals will be standardized as will a specialized test for ethylene evolution by stressed terrestrial plants.

The goal of the validation program is to assure that ORD-originated test methods are the best, most reliable, most cost-effective tests possible, thus encouraging their use by industry as well as by EPA and other federal agencies.

Heavy Metals

Heavy metals are widely distributed in aquatic systems and are known to harm fish populations by affecting their reproduction, growth, and survival. In a 1979 ORD program, the sublethal effects of copper on certain life stages of the Pacific salmon were studied to determine the effect of minimal exposures on the salmon's future survival.

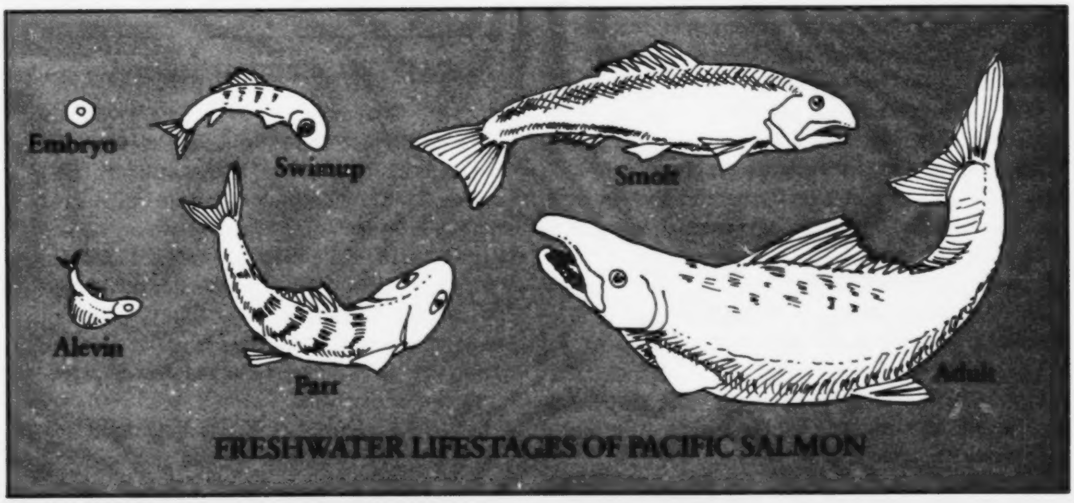
Results of the study indicated that young salmon in the smolt stage, ready to migrate from their birth streams toward the ocean, were particularly susceptible to the sublethal effects of the copper. Exposure prior to this migration resulted in a lower percentage of successful migrants and a higher percentage of smolt deaths from causes other than direct copper toxicity.

In addition, smolts exposed to copper just prior to entering seawater proved unable to survive the normal transition to a seawater environment due to their inability to maintain a proper internal salt and water balance.

Indoor aquatic testing facility

The salmon's swimup and young parr stages are susceptible to a virus disease called Infectious Hematopoietic Necrosis (IHN). Recent tests show that exposure to very low levels of copper lowers a salmon's resistance to IHN 100-fold.

Mortality from disease and migratory failure was produced by copper levels lower than any previously shown to harm salmon. These results emphasize the importance of testing sublethal effects of pollutants on each life stage of valuable aquatic species.



FRESHWATER LIFESTAGES OF PACIFIC SALMON

Airborne Asbestos

Asbestos or asbestiform minerals are a group of naturally occurring silicates with a distinct fibrous crystalline structure and special thermal and mechanical properties that have long encouraged their use in the manufacture of such products as roofing, insulation, brake linings, fireproof curtains, etc.

There is concern about the public health risks associated with the occurrence of asbestos in the ambient air and in supplies of food and drinking water. The concern is based on evidence that, occupational and paraoccupational exposures to asbestos have induced mesothelioma of the pleura and peritoneum, as well as cancer of the lungs, esophagus and stomach, after latent periods of about 20 to 40 years.

In support of EPA's effort to gather sufficient data for the promulgation of industrial and municipal wastewater asbestos discharge regulations

Electron micrograph showing Chrysotile Asbestos insulating material magnified 2000 times

ORD has developed a number of asbestos measuring and monitoring methods and aids. Of note, a recently completed study produced a procedure for optimizing the use of the electron microscope to identify and characterize asbestos fibers in ambient air and water samples. Traditionally, electron microscopy has been a relatively slow and expensive method, and often, because of variations in technique, results from two laboratories for the same sample differed significantly. The new ORD procedure was designed to diminish such discrepancies, and to improve method efficiency, while lowering costs.

A second ORD project saw the design and construction of a prototype asbestos analyzer that makes use of special X-ray diffraction optics. The analyzer can detect and measure submicrogram amounts of asbestos, and has demonstrated a potential ten-fold cost savings over electron microscopy, while requiring far less time for analysis.

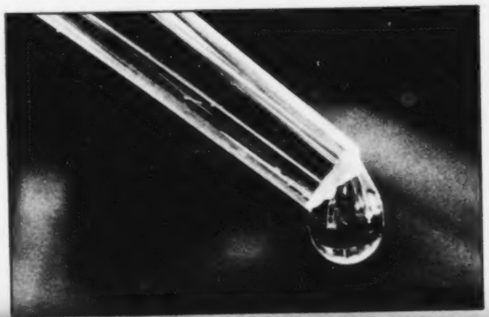
ORD has developed a number of asbestos measuring and monitoring aids

EPA has also designed and built an aerosol fiber counter that detects fibers (as opposed to other particles) based on their ability to scatter light. Initial tests indicated the counter was effective in the continuous monitoring for fibers and should be a useful tool for rapid screening and problem assessment, and for checking the effectiveness of control measures.

Hemoglobin as a Dose Monitor

How much of a given carcinogen can the human body endure before cancer and cell mutations result? This "dose" is far more than a function of mere exposure to the toxic chemical. Dose also depends on a system's contact with the chemical, its uptake and absorption of it, the distribution of the chemical in the body, and the metabolism of the chemical.

To determine the extent of the risk a given carcinogen poses to the public, researchers expose laboratory animals to the chemical, then extrapolate animal bioassay results to humans. To do so, however, requires an exact knowledge of the dose — in all its ramifications — administered in the animal studies. This often presents a problem. In the case of determining the carcinogenic potency of diesel exhaust, for example, the degree of exposure to the actual exhaust is known. But because



the carcinogens in the exhaust first bind themselves to particles before they are inhaled, the true dose of the carcinogens being administered is not known.

Thus ORD, in a recent research effort, sought to develop a *dose monitor* for use in animal and human studies that could bind itself to a carcinogen, and provide proof of the carcinogen's presence while serving as a measure of dose. A key 1979 result of this work identified hemoglobin as a promising dose monitor. Results from a study of 15 direct and indirect acting carcinogens demonstrated that a substantial fraction of these chemicals tended to attach themselves to hemoglobin.

Hemoglobin is highly useful in EPA's role of protecting the public health

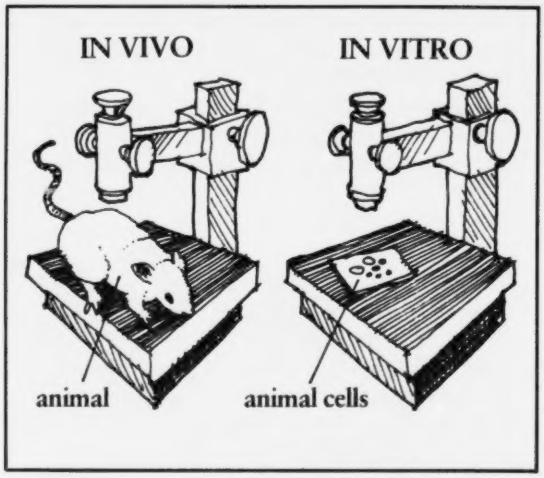
Still, many advantages accrue from the use of hemoglobin as a dose monitor. It is readily obtained from humans; the red blood cells normally discarded during a routine blood test are sufficient for a complete bioassay. And, once bound to hemoglobin, the carcinogen remains for months, allowing analysis long after exposure. The stability of this binding also allows for detection of low-level chronic exposure, whereas a single individual exposure might not have been detected. Additionally, the presence of carcinogens bound to hemoglobin relates directly to the degree of exposure.

These advantages and the fact that carcinogens representing many different classes bind to hemoglobin, potentially makes it a dose monitor highly useful to EPA in protecting the public health. Future work with hemoglobin as a dose monitor will involve a study of the binding to hemoglobin of benzo(a)pyrene in cigarette smokers and in laboratory animals exposed to diesel exhaust.

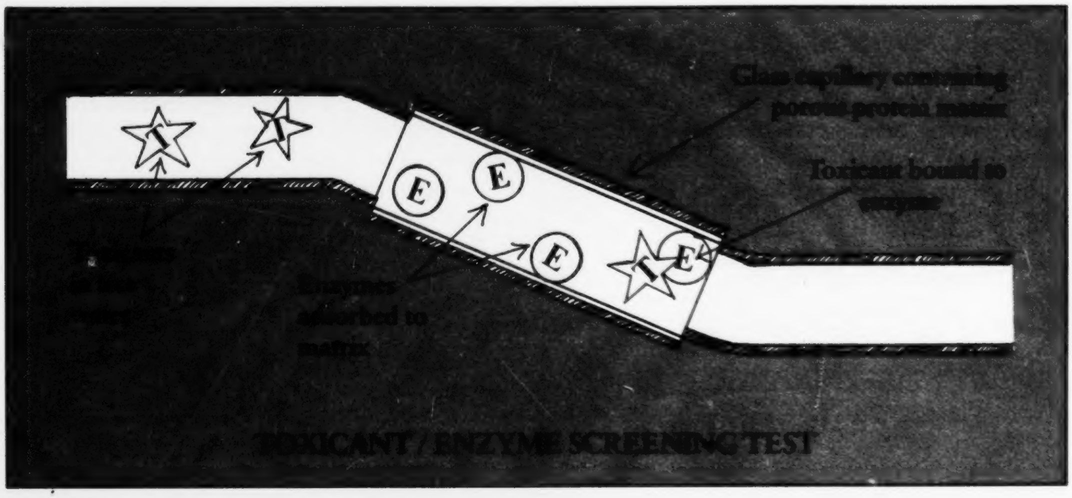
Molecular Indicators

With tens of thousands of chemical agents already in the environment and the introduction of some 600 new ones annually, a need exists for inexpensive short-term screening tests that can determine the presence of these chemicals and the hazards they pose as they react with the chemicals inside living systems. Unfortunately, today there is a general lack of knowledge to explain how these chemicals interact on a molecular level; how, for example, water toxicants affect the biological chemistry of fish.

Biochemists working at this molecular level are faced with a number of problems. Which method of *in vitro* testing, for example, will yield the results that can then most realistically be extrapolated to other organisms including humans? And, also, to determine the presence of toxics, what chemical in a living organism is the best indicator? Should suspect water samples be brought into contact with hormones? With liver slices? With cells *in vivo*?



A recent ORD research project attempted to provide some answers to these questions by developing a screening test that exposed various water toxicants to fish enzymes to determine, first, the efficiency of such a test, and, second, the viability of using enzymes as molecular indicators of a toxicant's presence. Enzymes were chosen because they are the known biological catalysts that control the rate of most metabolic processes.


Glass capillary containing porous protein matrix
Toxicant bound to enzyme
Enzymes adsorbed to matrix
T
E
TOXICANT / ENZYME SCREENING TEST

The test procedure involved placing enzymes contained in a porous protein mixture into a glass tube, then channeling water containing toxicants through the tube. After a specific amount of water was passed through the protein mixture, catalytic activity of the enzymes was measured. Any change in activity was noted.

The design of this screening test permitted analysis of 24 or more water samples in a one-hour period. Also evolved during the test was an enzyme combination that responded to most pollutants, thereby marking it as an effective indicator.

A second phase of this study, now in progress, compares these biological analyses to ongoing fish bioassay studies.

Test Protocols

Recently, ORD devised a set of laboratory techniques or *protocols* that can be used to estimate the potential exposure of humans and ecosystem organisms to newly developed organic chemicals. These protocols greatly improve EPA's ability to carry out its responsibilities as set forth in the Toxic Substances Control Act by allowing the relatively inexpensive and efficient testing of the hundreds of new compounds being introduced annually into the air, the land, and the water.

Because environmental exposure is directly related to a compound's persistence and its movement through the environment, the protocols were designed to determine a new chemicals' degradation and transport characteristics. Information obtained from applying these protocols to the compounds produces a rationale for separating them into three groups: those that require regulation to prevent unnecessary exposure, those that require no regulation, and those that require further testing and analysis.

Because of the high costs incurred in testing any new chemical, the protocols provide a two-tier system that eliminates the need for expensive testing of those chemicals that fall within certain parameters. In the first tier, relatively inexpensive, gross level tests provide a preliminary screening. If results from the tier-one tests are not conclusive for a chemical's classification, a costlier, more detailed set of tests is recommended.

This ORD protocol development effort contributed significantly to the official test methods for new organic chemicals recently promulgated in the Federal Register.

Laboratory hamster undergoing testing

Behavioral Teratology

In 1979, ORD designed a study to demonstrate whether a single exposure to a chemical toxicant during a critical developmental period can irreversibly alter sexual development in the rat and hamster. The purpose of this study was to evolve a similar bioassy method that could evaluate the power that a given toxicant could wield over a human fetus and its future ability to behave in a manner considered normal to its sex—i.e., male/female fertility characteristics, growth rates, etc. The critical period during which this behavioral differentiation occurs in the brain of the fetus is thought to be in the first trimester of pregnancy—in rats and hamsters it occurs post-natally, during lactation.

> Preliminary results indicated female rats' brains were more susceptible to chemical disruption

In the study, groups of rat and hamster pups were injected with either estradiol or kepone, both hormonally active chemical toxicants. Data were collected on growth rates, the age of vaginal opening, and open field activity. Preliminary results of the study indicated that females' brains were more susceptible than males' to chemical disruption during this period when behavioral differentiation takes place. Puberty in female rats was altered and they later became infertile. Female hamsters displayed abnormal bisexual behavior and altered ovarian cycles, and many had cystic ovaries. Female rats were "masculinized" as evidenced by increases in body weight and their "man-like" locomotor levels, rearing frequency, and scrabbling. In males, open-field behavior was unaffected, but at the highest doses some slight alterations in the reproductive system were noted.

Further behavioral abnormality research will study the effects of other chemicals, expand test procedures, and examine other species to ultimately develop a bioassay method that can adequately reflect the effects of toxicants on man.

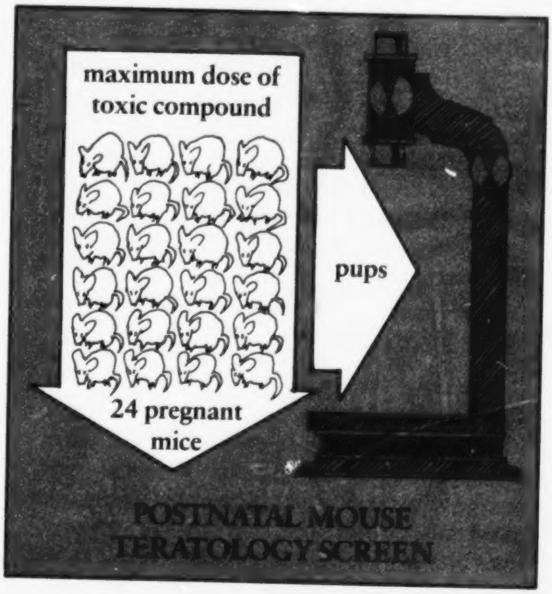
Postnatal Mouse Teratology Screen

To determine the potential of any substance to induce abnormalities in test animals a standard protocol is used which involves exposing pregnant animals of two or more species to three or more doses of the agent during the period of organ formation, and then examining the fetuses for any abnormalities. Such a teratology study takes three months to complete and currently costs $25,000 to $35,000 for a single compound.

Recently ORD, aware that the number of potential teratogenic chemicals was outstripping EPA's ability to perform teratology studies, sought to develop a screening system that would identify and prioritize those compounds in need of more detailed testing. As a result of this research effort, the Postnatal Mouse Teratology screen was developed in 1979.

The screening procedure involves administering the maximum tolerated dose of the compound in question to 30 pregnant mice on the eighth through twelfth days of gestation, then determining the percentage of dams littering, the average number of live and dead pups born per litter, the percentage of pups surviving three days of life, and the average weight of the pups on the first and third days following birth. The data are then compared with concurrent control group results.

Teratology study data can be used to evaluate a compound's potential developmental toxicity. Decreases in litter size, for instance, are generally an indication of severe toxicity causing embryonic resorbtions, later prenatal death, or cannibalization of malformed pups by the dam, while a failure to grow or survive over the 48 hours following birth may be due to heart, liver, lung or other organ malfunction, indicating a possible functional rather than a morphological effect. In essence, by using such measures as weight and litter size, the postnatal teratology screen allows the mouse's natural mechanisms to act as a substitute for the labor intensive and costly skills of technicians and teratologists ordinarily required for standard testing protocols. The screen also allows researchers to maintain newborn pups for further testing, an opportunity inherently lacking in *in vitro* tests.

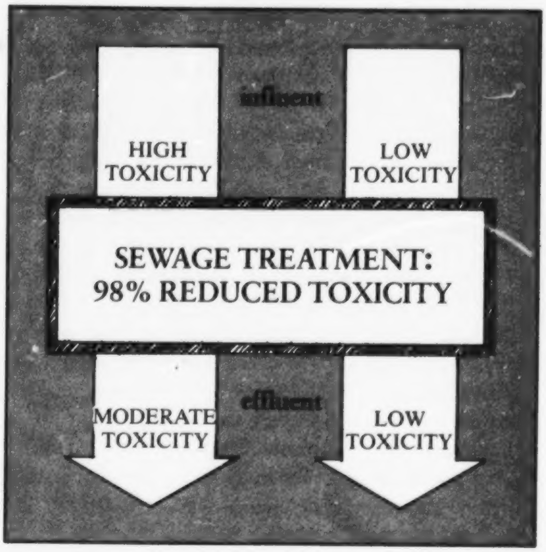


Following development of the screen, a validation phase was undertaken. Twenty-three compounds of varying teratogenic potential were tested with empirical results providing a high degree of agreement with results already established under standard protocols. All five compounds known to be teratogenic were positive in the screen. Of the 12 nonteratogenic compounds tested, 11 were negative in the screen and only one, kepone, was found to be positive. Of the remaining 6 tested for which standard protocols did not exist, 2 were positive and the remainder negative. Validation studies continue.

Since the screen can be administered for approximately 6% of the cost of a standard teratology protocol while requiring only one quarter of the time, it is expected that it has the potential for becoming an extremely useful toxicological testing tool.

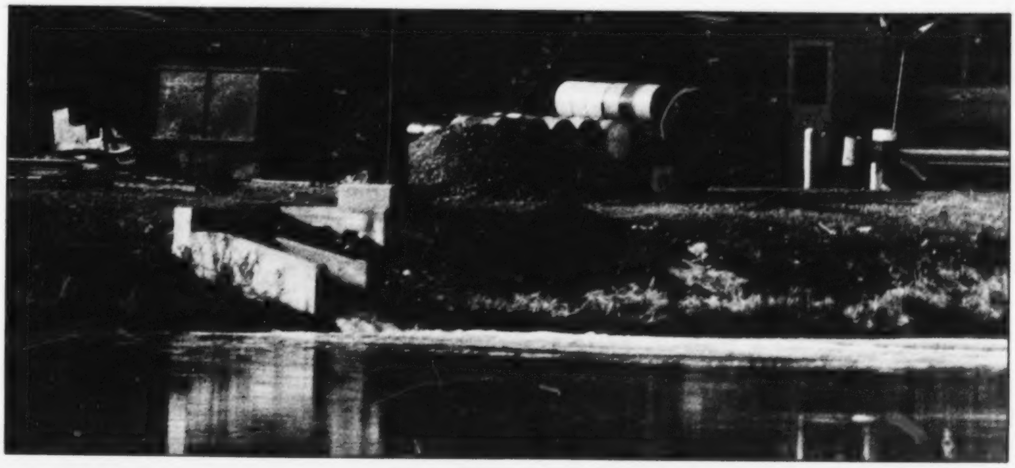
Complex Effluents

To present an alternative approach to the current method used by EPA and state programs for the protection of aquatic life in waters receiving complex industrial wastes, ORD has been giving recent attention to acute toxicity testing on fish and invertebrates to provide a good first cut evaluation of the potential hazards being posed by such discharges. Unlike current protective measures which specify effluent limitations for specific chemicals, these ORD tests did not single out any one effluent but instead made use of all the chemicals in test wastewaters in whatever concentrations they occurred. Another feature of the study was the use of species death as an endpoint to clearly allow the rapid identification of those complex wastes containing lethal chemicals. The length of time exposed species were monitored was 24 hours, a time favored by ORD in this research as a result of past study.



In 1979, to test this concept and to determine how effectively well-designed and operated wastewater treatment systems can reduce acute toxicity to aquatic organisms, ORD studied a number of industrial wastewater facilities. Twenty-four hour acute toxicity tests were conducted with fathead minnows twice daily on both treated and untreated effluent. Two daily 24-hour acute toxicity tests were conducted with the water flea.

Results from the testing indicated that the acute toxicity of the treated waste remained relatively consistent from day to day, while untreated wastes varied significantly. The average efficiency of the wastewater treatment systems in reducing acute toxicity ranged from 92% to 100%, with a mean reduction of 98%. Most significantly, data from the tested sites indicated that the acute toxicity of treated wastewater is relative to the toxicity of the untreated effluent. Thus, a highly toxic influent will still be moderately toxic even with a 98% reduction.



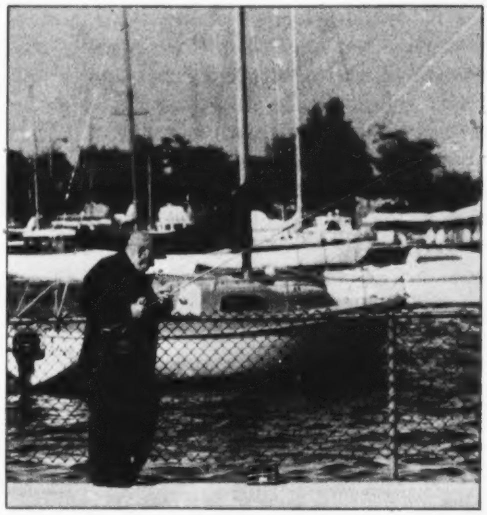
Ultimately, it is expected that acute toxicity tests will be integrated into effluent guideline systems and standards as a means to better control the discharge of toxic substances. This could be done by setting specific acute toxicity test performance levels that would have to be met. Levels would be arrived at by applying a formula that measures the lethality of wastewater before and after treatment. The formula would yield the percentage of the effluent volume that is lethal to 50% of the test organisms in a given time span.

Future study into the toxicity of industrial wastewater will involve development of more sensitive biological tests. These tests will also be relatively short-term and will expose organisms to sublethal levels of toxics and should prove valuable in determining the impacts on the aquatic environment of lower discharge concentrations.

Sudbury
Duluth
Toronto
Detroit
Chicago
Cleveland
GREAT LAKES AREA

Great Lakes

Results from a preliminary ORD study have shown the Great Lakes region to be a major problem area for human exposure to toxic substances. It also appears to be one of the few sites where inputs from sources of toxic substances can be ultimately related directly to human exposure. This offers the promise that critical doses of the substances can be estimated with a high degree of accuracy.

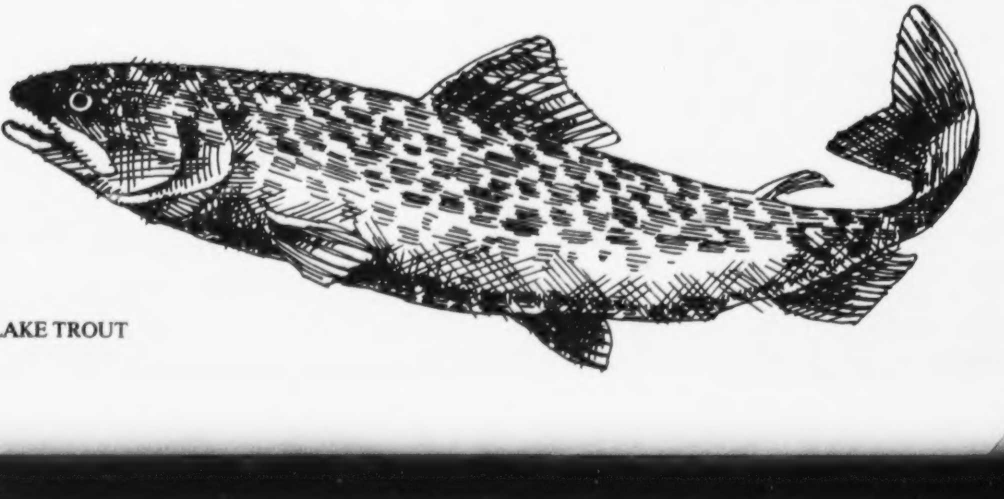


Fishing on the Great Lakes can be hazardous if too many fish are consumed in a year

In 1979 work centered around assessing the impact of a group of organic contaminants on human exposure. The presence of these substances was indicated by the polychlorinated biphenyl (PCB) molecule.

An ORD-sponsored study established that up to 95% of the PCB loading of the upper Great Lakes was the result of long-range transport mechanisms via the atmosphere, and that open water levels of this substance ranged from 4 to 10 nanograms per liter, a relatively low PCB level. Fish, however, bioconcentrated and bioaccumulated these toxicants and were shown to carry them in amounts exceeding 20 milligrams per kilogram, depending on the species. It was subsequently found that fish, in fact, were the major source of PCB exposure to humans residing in the region. Calculations show that the consumption of a one-pound meal of Lake Michigan lake trout would present the same risk to exposure as a full five years of breathing ambient air and drinking water from local supplies.

These results provoked concern over human fish consumption levels, particularly among the hundreds of thousands of licensed sportsfishermen in the region. The Michigan Department of Public Health has established a maximum safe consumption rate of 24 pounds per year, with the recom-



LAKE TROUT

mendation that expectant mothers avoid exposure entirely. A preliminary survey in the region, however, observed mean consumption in the area to be 36 pounds per year, with a range of between zero and over 100 pounds annually.

Preliminary results from blood sampling by the Michigan Department of Public Health revealed a significant difference between levels of PCB in humans in direct relationship to the amount of lake fish consumed. Also discovered was that following removal of fish from the diet, PCB persisted in the circulatory system for as long as two years after initial exposure.

The Great Lakes region is a major problem area for human exposure to toxic substances

The most disturbing of the research findings, however, concerned infants and small children. Studies have demonstrated that from conception to birth the fetus is exposed to approximately 75% of the mother's circulating blood titer of PCB compound. Preliminary results of Great Lakes region breast milk studies for mothers in the high exposure range from lake fish consumption, indicated an average value of 4 to 6 parts of PCB per million. This value represents an effective dose to the average newborn infant of more than 1500 times the maximum allowable PCB dose rate for 70-kilogram adults established by the Food and Drug Administration.

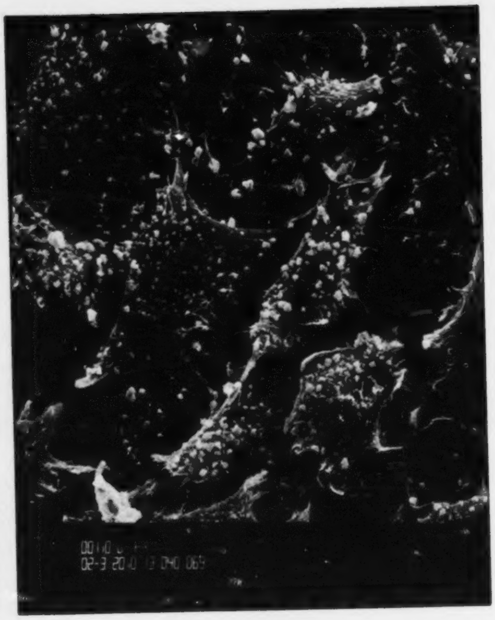
The situation is further complicated by the fact that these massive doses occur during formative stages and in periods of intense growth and maturation of tissues. Thus the potential for significant long-term impacts of PCBs on the human community exposed in this way is substantially increased.

In a related development, in 1977 ORD provided technical assistance and field study coordination for Region V following the industrial disposal of more than 7,000,000 pounds of PCBs to landfills, the atmosphere, the Waukegan Harbor, and a small tributary to Lake Michigan. Sediments in the harbor were found to contain as many as 4000 ppm PCB, which was being gradually leached into the overlying water. Field studies were aimed at determining the significance of the harbor sediments as potential sources of PCBs to the lake. The effect of dredging the harbor to remove the contamination was also studied.

Short-Term Tests

When a chemical demonstrates the ability to damage the genetic material (DNA) of a cell it is considered to be genotoxic. Since DNA controls the genetic make-up of an organism, even a small change in this material can have severe consequences for the organism or its offspring. The key to short-term testing for genotoxicity is the fact that the fundamental structure for DNA is the same in all organisms. Thus, a chemical that affects the DNA of a single cell in a short-term test will theoretically have a similar effect on the DNA of an exposed human.

Normal mouse embryo fibroblasts multiplied 3000 times



Transformed mouse embryo fibroblasts multiplied 3000 times

Using such short-term tests instead of long-term tests results in a significant savings in performance time and cost, and consequently ORD has sought to make use of these testing procedures whenever possible, particularly in the screening of chemicals that may pose a mutagenic or carcinogenic threat. Over the last few years, significant advances have been made in the development of methods for assessing such a threat. Short-term tests now available can detect alterations to genes, chromosome damage and primary damage to DNA. Genetic activity and/or mutations observed in these tests can then be used by researchers to predict a compound's potential carcinogenicity.

In carcinogenicity testing a three-tiered approach is generally used: detection at the first tier, verification at the second, and hazard or risk assessment at the third. Mutagenicity is determined using a set of tests capable of determining gene mutation, chromosome damage and primary DNA damage.

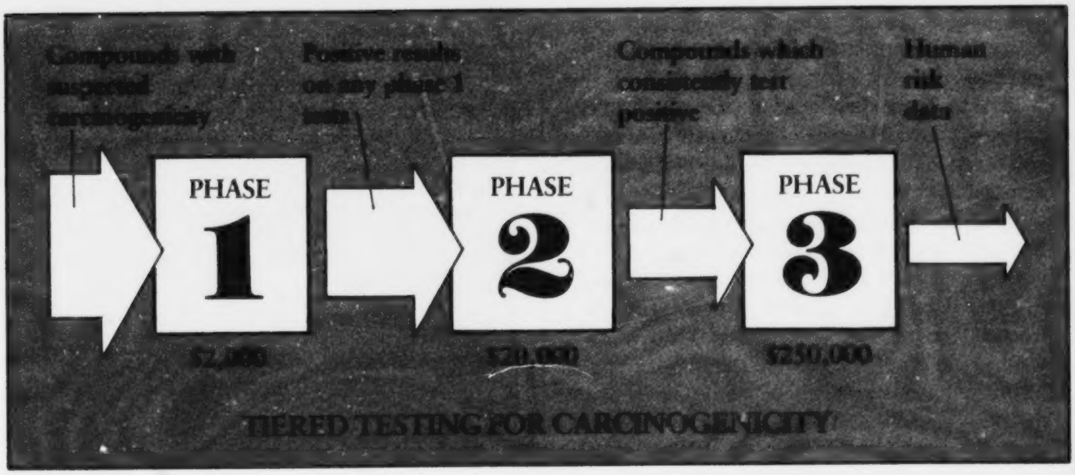
In the ORD-developed phased approach to evaluating compounds as mutagens and potential carcinogens, tiered testing for carcinogenicity is combined with battery testing for mutagenicity. This approach defines three separate testing phases, the first two of which have their own set of short-term tests. Phase One, the detection phase, involves the detection of gene mutations and DNA damage in microbes and chromosome alteration in mammalian cells. Costs of Phase One tests are on the order of $3000 or less. Positive results on any of the Phase One tests lead to Phase Two testing, which involves short-term tests using cell transformation in mammalian cells, insects, and *in vivo* short-term tests on plants. Phase Two tests are used to confirm the effects detected in Phase One and to characterize more specifically the nature of the effects (i.e., whether the chemical is potentially carcinogenic or mutagenic, or neither). Costs of these tests run approximately $30,000. Phase Three testing is performed on those priority compounds that test positive in Phase Two. These tests are generally whole animal studies using rats or mice to validate the hazard posed by the compound and to make a quantitative assessment of the risks it presents. Such studies may cost $300,000 or more and may take several years to complete.

Recent ORD applications of the phased testing approach on 38 pesticides and on diesel exhaust have demonstrated the efficiency of the approach and have contributed to an increased understanding of the sensitivity and adaptability of short-term tests. The pesticide study pointed to the validity of applying the phased approach to short-term testing, particularly when large numbers of chemicals must be tested rapidly and efficiently.

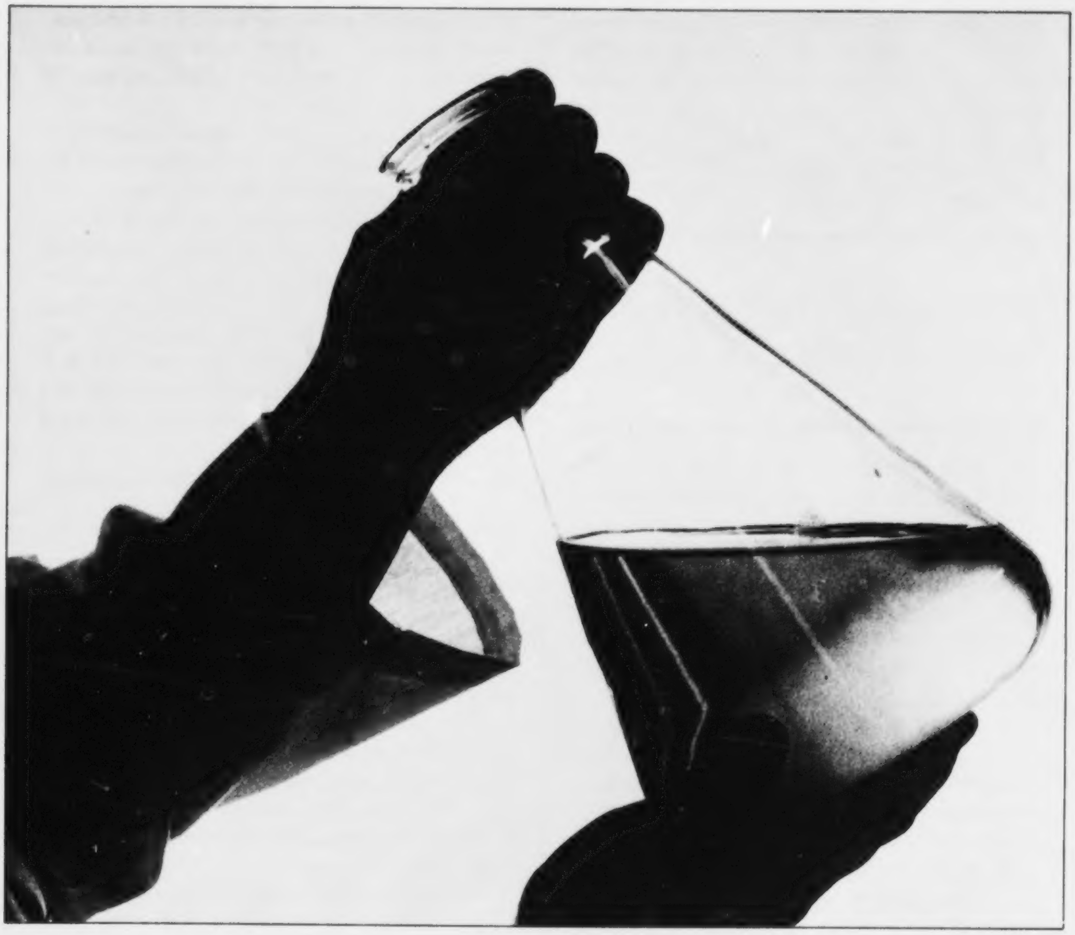
The diesel exhaust program, still in progress, has demonstrated the ability of short-term tests to indicate that a potential hazard exists in a complex mixture such as diesel exhaust; and when such a hazard does exist, the short-term tests can prove valuable in pinpointing those chemical fractions within the mixture responsible for the hazard.

The following ORD components contributed to the research described above:

- Office of Environmental Processes and Effects Research, Environmental Research Laboratories, Duluth, Cincinnati, Gulf Breeze, Corvallis, Athens,—Environmental Sciences Research Laboratory, Research Triangle Park
- Office of Environmental Engineering and Technology, Industrial Environmental Research Laboratory, Cincinnati
- Office of Health Research—Health Effects Research Laboratory—Cincinnati and Research Triangle Park


Compounds with suspected carcinogenicity
Positive results on any phase 1 tests
Compounds which consistently test positive
Human risk data
PHASE 1
PHASE 2
PHASE 3
$2,000
$20,000
$250,000
TIERED TESTING FOR CARCINOGENICITY

ANALYTIC TECHNIQUES



ORD improves and refines its methods to insure accurate and efficient pollutant research

Behind every pollutant that EPA studies, and behind every standard that EPA sets, are a complex series of analytic techniques and testing methods to assure proper measurement, accurate monitoring results, precise instrumentation, calibration, and cost-effective and efficient pollutant analysis procedures. In 1979, several improved analytic techniques were developed or refined.

Toxic Compound Analysis

When EPA signed a consent decree to establish stringent wastewater discharge standards for 65 compounds and elements considered harmful to aquatic and human populations, the EPA Effluent Guidelines Division was charged with the responsibility for developing the standards. ORD, in direct support of those standards, began developing monitoring methods for these priority pollutants.

The challenge to ORD was to develop test procedures that could measure small amounts of toxic substances in the wastewater discharges of 21 different industrial categories, from auto laundries to pulp mills. The test methods had to be reliable and accurate, and had to rely on readily available laboratory instruments and skills so as not to place unreasonable economic burdens on the industrial discharger, state monitoring agencies, and the EPA laboratories charged with determining compliance to the standards.

114 organic compounds were identified for testing

A number of items on the list of 65 toxic substances were groupings of compounds that had to be isolated to specific chemicals before monitoring could be carried out. Ultimately, 114 organic compounds, some of them cancer-producing, and 15 metals were identified for testing. To facilitate this testing, the 114 organics were grouped into categories based primarily on similarity of chemical structure.

By mid-1979, the first phase of the test procedure work was complete. In this phase, methods were developed to refine and optimize samples processing and testing techniques for each compound. The majority of the procedures made use of the gas chromatograph for measurement. In the gas chromatograph, individual compounds are separated based on the speed at which they pass through a long narrow column packed with a chemical filter. Two of the categories of compounds required the use of high pressure chromatography with a liquid filter; dioxin, the most highly toxic substance under test, required use of the gas chromatograph in combination with a mass spectrometer, a device that breaks compounds into fragments for an even more refined measure of their type and concentration.

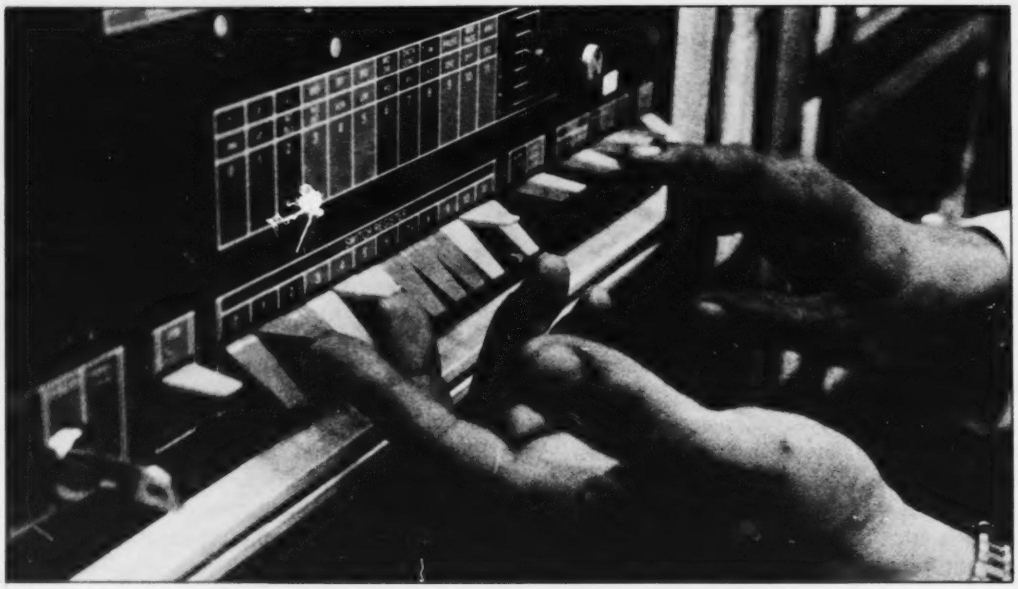
Still to be completed is the second major step of the operation, which involves application of the test procedures to actual samples from many of the 21 types of industrial wastewaters. As a necessary prelude to this step, ORD is currently conducting interlaboratory studies to establish the precision and accuracy of the test procedures in a large number of laboratories. The final product, expected to be completed by 1981, will include a complete method description with supporting data on the usefulness of the procedures in wastewater monitoring.

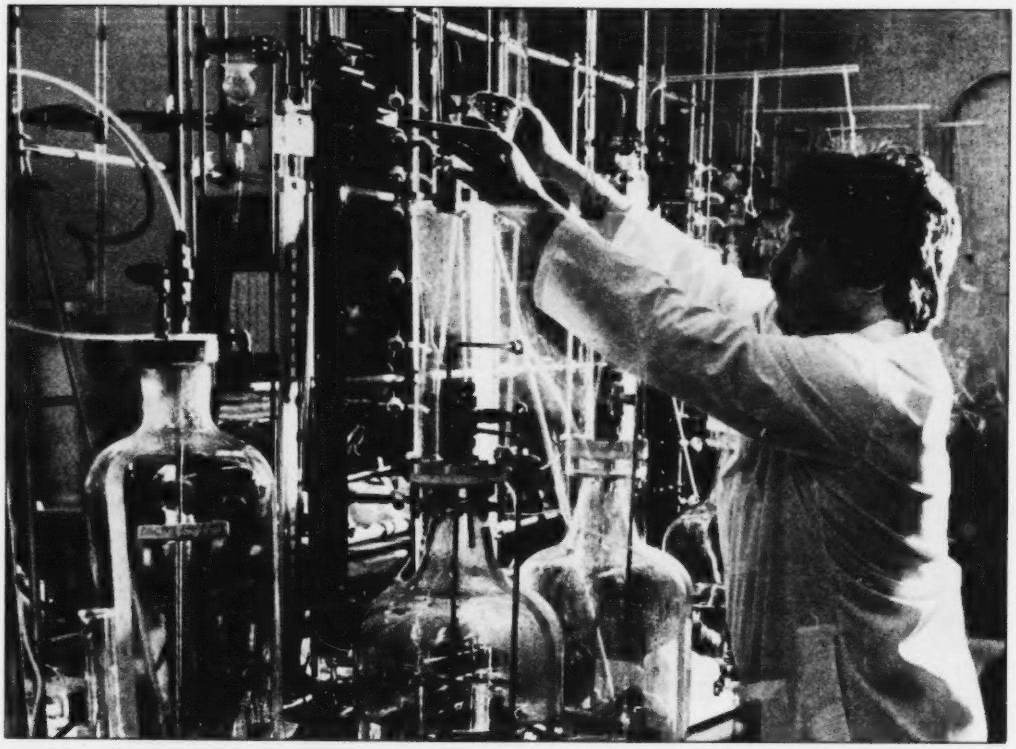
Undetected Pollutants Now Measurable

Liquid chromatography, like gas chromatography, is a recognized laboratory procedure for separating and identifying pollutants in water. In 1979, ORD scientists evaluated two new liquid chromatography methods to help EPA determine whether some pollutants suspected to be in certain industrial wastewater discharges but undetected by existing analytical techniques did, in fact, exist in the water effluents.

The first method employed a new commercially-available material which makes the liquid chromatograph/mass spectrometer analytical

Data processing has become an important part of analytic testing





combination better able to detect non-volatile organic compounds. Five water samples taken from the wastewater discharges of the leather tanning and finishing industry were analyzed for these compounds using the new system. Eleven compounds have been identified to date including three compounds never before reported in environmental samples. This method represents the first time extracts from samples have been separated by liquid chromatography and analyzed directly by mass spectrometry.

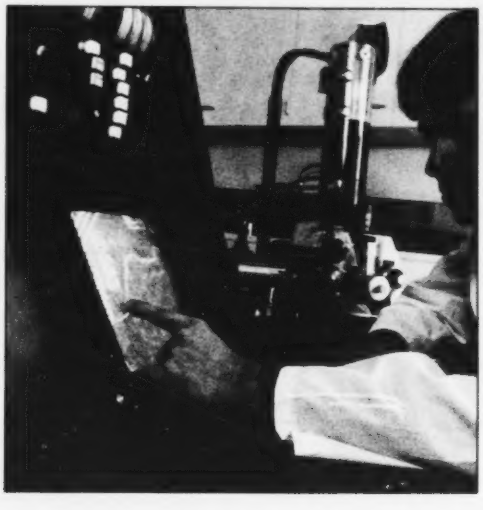
The second method used a high pressure liquid chromatograph to detect nitrophenols in drinking water, municipal effluents and industrial discharges. Nitrophenols are potential carcinogens used in the manufacture of dyes and explosives. They are also formed as decomposition products of some pesticides.

The ORD procedure now enables measurement of nitrophenol concentrations down to 0.1 ppb for a specific nitrophenol. Future work will be devoted to measuring even lower concentrations of these hazardous compounds.

Ozone Calibration

A three-year ORD study culminated recently when EPA replaced its long-standing ozone (O_3) calibration procedure with a more accurate and precise method to measure ozone in the atmosphere.

Measurement for O_3 is carried out by first calibrating an ozone analyzer with a known O_3 concentration and then using this reference in measuring the ambient air. This is complicated by the fact that no standard reference material for O_3 exists due to the pollutant's instability and its consequent resistance to storage. Thus, to calibrate the analyzer, standard samples have to be generated and assayed at the time and place of use. The accuracy of ambient O_3 measurements depends on the accuracy of the assay method used to calibrate the analyzer.



Electron Microscope display

Formerly, this calibration procedure was based on assay of O_3 concentrations using potassium iodide. However, it was found that this procedure resulted in significant degrees of error and variability, particularly when used under field conditions.

To ensure more reliable air quality measurements, ORD took ozone calibration under study in 1976. Four new calibration procedures were documented and evaluated. Each procedure first underwent study by a single investigator, which determined its overall acceptability. Then a second study was conducted using typical air pollution equipment and experienced air pollution measurement personnel to determine the degree to which calibrations might vary from user to user.

Results of the evaluations clearly indicated that an ultraviolet (UV) photometry technique was the most accurate and least variable of the four procedures studied. The UV procedure makes use of the ability of O_3 to absorb UV light. The O_3 absorption characteristics can then be translated into accurate assays of sample O_3 concentrations used to calibrate ozone analyzers. In February 1979, EPA adopted the procedure.

Additionally, the accuracy of the new O_3 calibration procedure allows a standard established at one location to be transferred for use at another location. The implementation of such transfer standards offers state and local agencies important benefits including easier operation, and greater flexibility in the performance of their air monitoring responsibilities.

Technician using an electron microscope

Atmospheric ammonia may be a key constituent in the pollutants Sulfate, Nitrate and Acid Rain

Monitoring Ambient Ammonia

Atmospheric ammonia may be a key constituent in the formation of sulfate aerosols, nitrate aerosols and acid rain. To determine the role ammonia plays in the airborne amounts of these pollutants EPA must measure the concentration of ammonia in ambient air. Normal levels of ambient ammonia, however, are very low; therefore, measurement and analytical techniques must be quite sophisticated and sensitive. ORD has developed such a technique.

The ORD technique involves passing an air sample through a tube containing an ammonia sorbant, a material that successfully captures the ammonia in the air. By passing a large amount of air through the tube, the ammonia becomes concentrated on the sorbent, which is then heated to release the ammonia in sufficient quantities to be detected by either chemiluminescence or optoacoustic methods. The known amount of air that was passed through the tube and the amount of ammonia that was released and measured is sufficient information to describe the concentration of ammonia in the original sample.

This analytical technique has been used to successfully measure average ammonia concentrations of 1 part per billion (ppb) and peak concentrations up to 10 ppb. The increased monitoring and analytical flexibility achieved by this methodology will enable EPA to better understand the effects of ammonia on air pollution.

The following ORD components contributed to the research described above:

- ■ Office of Monitoring and Technical Support—Environmental Monitoring and Support Laboratory, Cincinnati; Environmental Monitoring Systems Laboratory, Research Triangle Park
- ■ Office of Environmental Processes and Effects Research—Environmental Sciences Research Laboratory, Research Triangle Park; Environmental Research Laboratory, Athens

RESOURCE CONSERVATION AND RECOVERY ACT

Research and supervision by ORD personnel contributes to the recovery, reuse or safe disposal of wastes

The Resource Conservation and Recovery Act was passed into law in 1976 to: a) provide technical and financial assistance for the development of management plans and facilities to recover energy and other resources from discarded materials and to safely dispose of discarded materials and b) regulate the management of hazardous wastes.

The objectives of the Act include the regulation of hazardous wastes, the setting of guidelines for solid waste disposal, the monitoring of grants for development of solid waste disposal systems, and the promotion of a national research and development program for improved solid waste management and resource recovery and resource conservation systems to preserve and enhance the quality of the environment. Primary responsibility for the accomplishment of these objectives lies with the EPA.

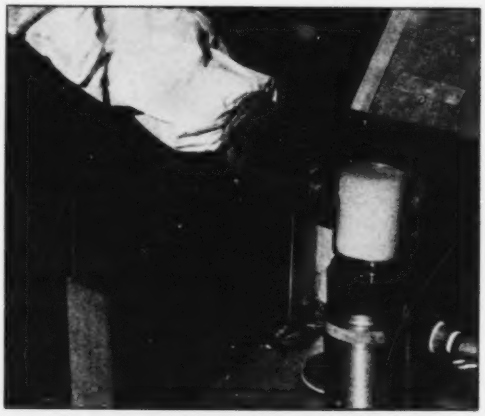
In support of the effort, and to rectify past errors and improve future practices, ORD is to provide the human health and environmental data necessary for the informed setting of standards, guidelines, criteria, and regulations. Additionally, ORD will supervise contract work with a large number of researchers and will perform in-house studies and research into improved waste disposal, waste management, and resource recovery and conservation systems.

One of the grimmest discoveries of our decade has been the severe threat to public health and the environmental problems now occurring because of past mismanagement of hazardous waste. Love Canal, the Valley of the Drums and other hazardous waste incidents have received wide media coverage which has served to remind us of the consequences of improper disposal of hazardous waste. EPA is proceeding to discover remedies for existing sites that endanger public health and welfare.

Responding to Past Problems

Safety and Hazard Guide. When EPA or other federal, state, or local agency personnel are called in to monitor or participate in the clean-up of hazardous material, they are often exposed to dangerous chemicals in volatile situations. To help assure the safety of workers taking part in such activities and to further their understanding of the hazardous materials involved in spills, in 1979 ORD published the two-part Hazardous Materials Spill Monitoring Safety Handbook and Chemical Hazard Guide.

Protective clothing is often a necessity when dealing with hazardous materials



Technician installing a new filter in ambient air monitoring equipment

To prepare the Guide, an effort requiring two years, researchers extensively reviewed spill histories to determine the hazardous chemicals involved, their identifying characteristics, the degree and nature of the hazard they posed and the frequency of occurrence of the given chemicals in spills. Appropriate preventive and first aid measures were also studied.

The Hazard Guide portion of the handbook consists of a listing of the chemicals addressed and individual chemical data sheets for 655 specific chemical compounds. These data sheets contain information on the nature, degree of hazard, and exposure and safety precautions to be taken for each of the chemicals.

Degree of hazard information for the chemicals is summarized when available, using the National Fire Protection Association hazard identification system, which defines three categories of concern: a chemical's toxicity, its flammability, and its reactivity. In the Guide each of the 655 chemicals is rated in each of these categories on a scale of 0 to 4, with 0 representing no hazard and 4 indicating severe hazard or extreme danger.

Also included in the Hazard Guide is a priority listing of hazardous substances subject to being spilled, based on previous spill data. The objective of such a listing is to direct the attention of Guide users to those chemicals most likely to be encountered and the corresponding safety and protection measures required during monitoring and clean-up operations.

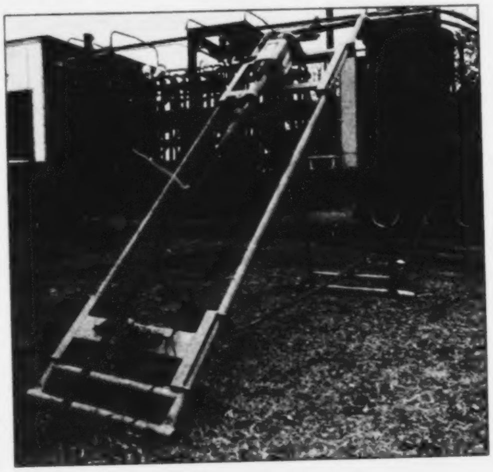
The suggested first aid measures contained in the Safety Handbook portion of the Guide have all been proven effective but are not intended to replace professional medical attention. Rather, they appear so that personnel who sustain an injury or acute exposure to a particularly toxic substance can take the immediate and correct life-saving steps necessary.

The 707 page handbook provides a wealth of information to lessen the chance of accident or exposure and to minimize the effects of such an accident if it does occur.

Mobile Soils Grouting and Detoxification. To rid an area of soil contaminated by hazardous wastes requires that the soil first be excavated and then disposed of, both costly procedures. A recent ORD development, however, allows for decontamination of soil *in situ* (in place). Such innovative treatment is made possible by the use of a mobile pumping system capable of the high-pressure injection of chemicals or grouts into the contaminated soil. In 1979, ORD worked with the mobile system to prepare it for future use in emergency situations at chemical and waste disposal sites.

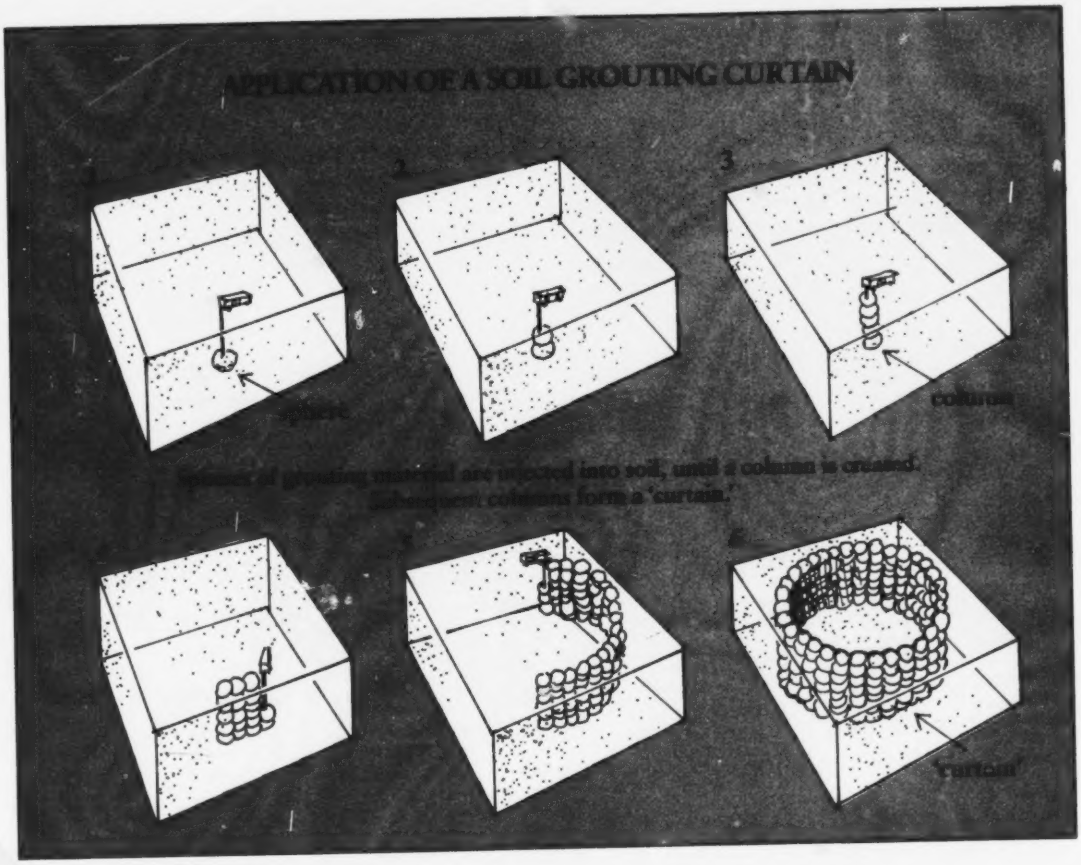
The grouting concept, used for years by the construction industry to consolidate soils or divert groundwater supplies, involves injecting certain liquids, plastics, or particles into the soil to fill underground voids. The ORD system makes use of this concept for the clean-up, control, or detoxification of underground wastes by using grout curtains to surround and isolate contaminated areas or by deep-injection of certain chemicals known to be capable of safely treating impacted areas.

The system to accomplish this consists mainly of mixing, piping, and pumping equipment all mounted on a trailer. Two types of pumps are used: one kind to pump grout and the other to handle soils detoxification chemicals.



Mobile Soil Grouting Unit

To surround a spill with a curtain, grout material such as bentonite or a cement slurry is pumped through a pipe driven into the soil. The grout permeates the soil at the end of the pipe, creating a sphere with a 3- to 6-foot diameter. The pipe is then withdrawn slightly and a new injection is made above the first. Eventually this results in a column of grout spheres, one on top of another. A curtain is formed when a number of these columns interlock.


APPLICATION OF A SOIL GROUTING CURTAIN
2
3
sphere
column
Spheres of grouting material are injected into soil, until a column is created.
Subsequent columns form a 'curtain.'
5
6
'curtain'

To use the system to detoxify contaminated soil, slotted or perforated pipes are inserted into a series of holes drilled into the impacted area. Water is then pumped through the pipes to wash the soils. Chemicals may be added to this water to achieve neutralization or other chemical reaction, while microbiological agents may be introduced to biodegrade contaminants.

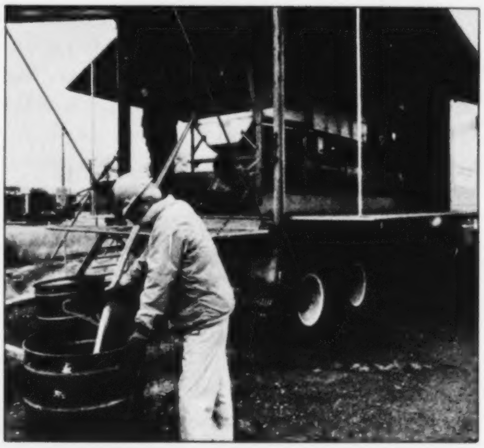
Future ORD testing of the system to gain experience with the technique and ultimately to make the technology available to the pollution control industry involves soil evaluation studies and research into grouting materials and various contaminated soil neutralization methods.

Mobile Carbon Regenerator

Mobile Carbon Regenerator. When a spill of hazardous wastes occurs, or when toxic wastes at an abandoned dump site endanger the environment and threaten human health, ORD is capable of a quick response with its Mobile Physical/Chemical Treatment System. This system makes use of granular activated carbon (GAC) to remove hazardous organic chemicals from aqueous solutions. Pollutants are adsorbed physically to the carbon surfaces as the liquid passes through the GAC. What remains is a quantity of GAC loaded with contaminants.

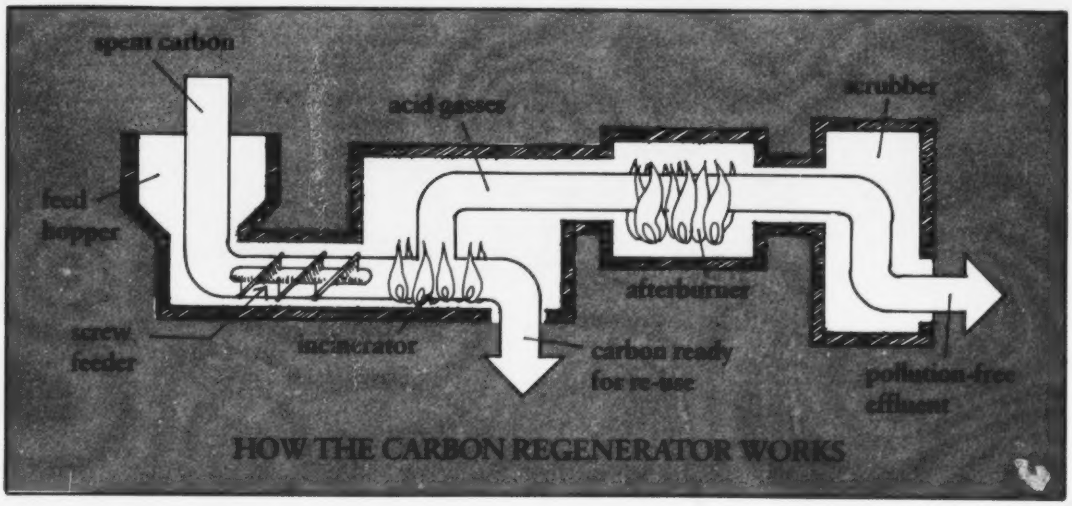
To augment this system, in 1979 ORD developed and tested a mobile carbon regenerator, capable of treating this leftover carbon to remove contaminants and thus regenerate the GAC for reuse. To eliminate problems associated with the transport of contaminated GAC from the spill site to a regenerating facility, the entire carbon regeneration system is contained within a single mobile van.

Equipment in the van includes a carbon feed hopper, a primary kiln, an afterburner, a gas scrubber, a water-filled quench tank, and various analytical and screening equipment and facilities.



The spent carbon is first drained of excess water and then introduced into the feed hopper where a screw feeder meters the carbon into the kiln. Carbon retention time in the kiln is twenty minutes at approximately 1800°F. Under these conditions the pollutants are desorbed from the carbon and partially combusted, after which they are incinerated in an afterburner designed to totally decompose organics. The acid gases that are generated in the afterburner are then quenched with water sprays and channeled through a flue gas scrubber to neutralize acids and remove particulates. The hot carbon is also quenched in water and is then available for reuse. During the operation all effluents are monitored to assure pollution-free GAC regeneration.

Capacity of the mobile regenerator is 210 pounds of spent carbon per hour, which breaks down to 120 pounds of spent carbon, 10 pounds of hazardous substances, which have been captured



HOW THE CARBON REGENERATOR WORKS

by the carbon, and 80 pounds of water. It is estimated that, while some carbon is lost through oxidation in regeneration and the capacity of the remaining carbon to absorb wastes is diminished, one pound of regenerated GAC is still equivalent to at least 0.9 pounds of virgin GAC.

In addition to its efficiency, the system produces regenerated GAC cost effectively. This, along with its ability to make the carbon ready for immediate reuse will stimulate interest in the system for spills clean-up applications and will allow ORD teams to respond even more effectively to hazardous waste emergencies.

Technician operating Mobile Carbon Regenerator

Improving Waste Management

Classification Methods. In response to the mandates of the Resource Conservation and Recovery Act (RCRA), EPA recently called on ORD to assist in the development of regulations for the high volume wastes generated from coal-fired power plants. The primary objective of the resulting ORD study was to determine whether or not wastes such as coal ash or flue gas desulfurization (FGD) waste were hazardous.

To generate the necessary information, three projects were initiated in 1979. First, a study was conducted to develop data on the coal-fired utility industry for a long-term waste management plan, this to evolve some general waste disposal truths or identify key information gaps. One such gap, for example, indicated by the study was that there was insufficient hydrological data on existing power plant wastewater disposal sites to determine whether RCRA performance criteria were being met.

The second project involved the testing of power plant wastes for toxicity; fly ash, bottom ash, and FGD wastes from a single TVA plant were tested. Results showed all three samples to be non-hazardous; however, since fly ash came closest to failing the test, a second sample from another plant is currently being studied.

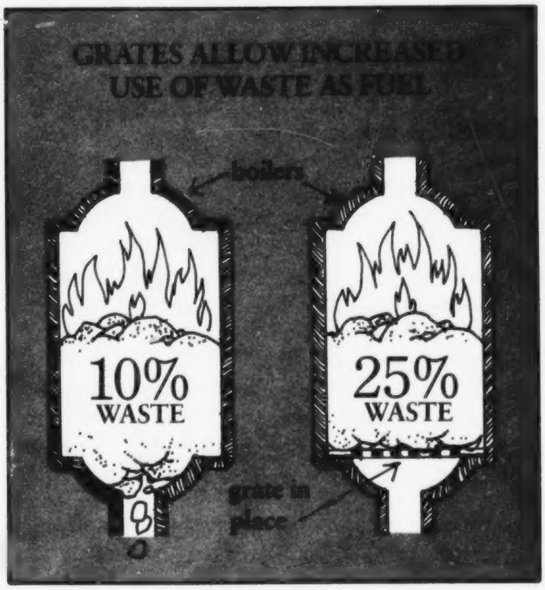
The third and largest project in this ORD data-generation effort began in 1979 and will be completed by 1981. It involves characterizing and monitoring 16 coal-fired electric utility coal ash and FGD disposal sites to obtain the full-scale field data necessary for EPA to promulgate regulations to manage these wastes. Sites studied represent an industry cross-section and include prevalent disposal methods as well as those disposal technologies most likely to be used in the future.

Wastes as Fuels. When the problem of diminishing fuel sources is linked innovatively to the problem of finding environmentally acceptable solid waste disposal methods, a single, albeit partial, solution to both emerges: use waste as fuel. This potentially beneficial conversion plays a significant part in ORD solid waste disposal efforts. Overall this work is concentrated in four study areas:

- Emissions testing and assessment of wastes-as-fuels processes
- Development of waste/conventional fuel co-firing technology
- Development of high temperature waste-to-fuel conversion technology
- Development of appropriate pollution controls

In 1979, research on waste/fuel co-firing technology resulted in a major breakthrough in the use of wastes as fuel along with coal in a pulverized-coal boiler. The key to this development was the installation of special bottom dump grates that were capable of retaining larger particles of refuse in the boiler long enough to assure their more complete combustion. Prior to the installation of the grates, only 10% of the coal could be replaced with waste while still maintaining an efficient combustion level. With the grates, the replacement rate grew to 25%, resulting in both a more efficient use of coal and a consequent lowering of pollution levels. Installation of the grates also reduced ash generation and facilitated ash removal. Since pulverized coal boilers represent the largest

> The success of this co-firing technology may well alter the nation's energy future



number of boilers in operation, the success of this co-firing technology may well alter the nation's energy picture.

Additional recent waste-as-fuel program work includes:

- Characterization of the pollutants emitted from six separate waste-as-fuel systems
- Construction of a pilot plant to establish the technical, environmental, and economic worth of converting low density wet agricultural wastes, such as rice and wheat straws, to fuel oil and char
- Construction and testing of a fabric filter to determine its capability of removing lead emissions
- Design of a mobile van to investigate water pollution control technologies for waste-as-fuel process wastewaters

Results from the ORD waste-as-fuel program will be presented in April 1980 at the "Waste to Energy Technology: 1980 Update" conference.

Scrap Futures. One of the major risks in commodity futures such as butter, soybeans, or coffee is the ever-present possibility of price movements unfavorable to either buyer or seller. To hedge against this risk, these commodities are made available to speculators to buy and sell prior to the actual delivery of the commodity sometime in the future. The incentive for speculators is that commodity prices at the time of delivery may be higher than at the time of purchase, and that their consequent sale of the commodity will yield them a profit. With speculators thus assuming the risks, commodity prices tend toward greater stability and commercial buyers and sellers are offered a measure of security.

In 1979, ORD conducted a symposium which brought together a number of major consumers and suppliers of metal scrap and wastepaper to discuss the feasibility of a scrap futures market. The purpose of such a market would be to encourage and expand the use of secondary materials such as iron scrap or wastepaper in industry operations. Speakers included Commodity Exchange (COMEX) members, selected industry members and representatives of the Department of Commerce.

Discussions dealt with the mechanics of futures trading, scrap grade requirements, delivery points, trading margins, transportation modes, and how such futures trading could facilitate industry decisions about the use of secondary materials. An EPA-prepared handbook on scrap futures trading served as a focus for the discussion.

Attendees were generally impressed by the scrap futures markets concept, and COMEX of New York subsequently announced it was giving serious consideration to iron scrap futures trading.

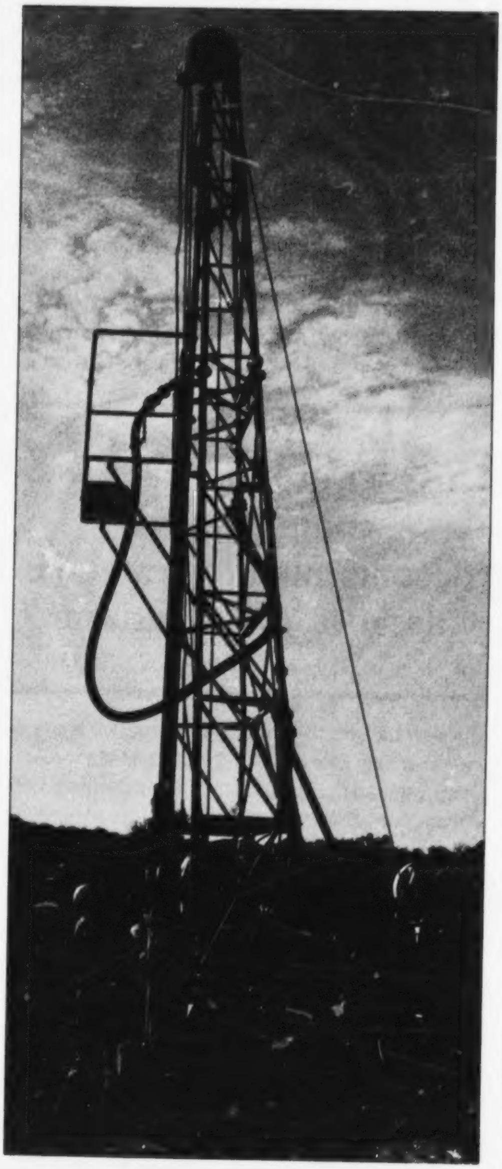
A potential market exists for secondary materials such as iron scrap

Deep-Well Injection. For years, industry has used deep-well injection to dispose of fluid wastes, ranging from oil field brines to radioactive material, deep below the earth's surface into porous rock. While supporters of the process consider it a harmless and economical use of the subsurface of the earth, detractors fear that the fluids injected under pressure might move laterally through the geologic strata and into improperly constructed or unplugged wells. The formation fluid and/or fluid waste would then be free to move upward where it could contaminate subsurface water supplies.

A number of instances of environmental damage have already been recorded as a result of deep well injection activity. In 1968, a well in Erie, Pennsylvania, into which a paper company had been injecting 150,000 gallons of waste a day, suddenly sent up a geyser 20 feet into the air. An estimated four million gallons of contaminated fluid gushed out in the three weeks it took before the well could be tapped. Another hazard of deep-well injection was revealed in 1968 when the U.S. Army, disposing of its nerve gas arsenal in Denver, Colorado, pumped the waste into very deep wells under extremely high pressures. The waste apparently lubricated an unknown earthquake fault, resulting in a series of small but significant earthquakes in the Denver area. The pumping was stopped and the earthquakes ceased.

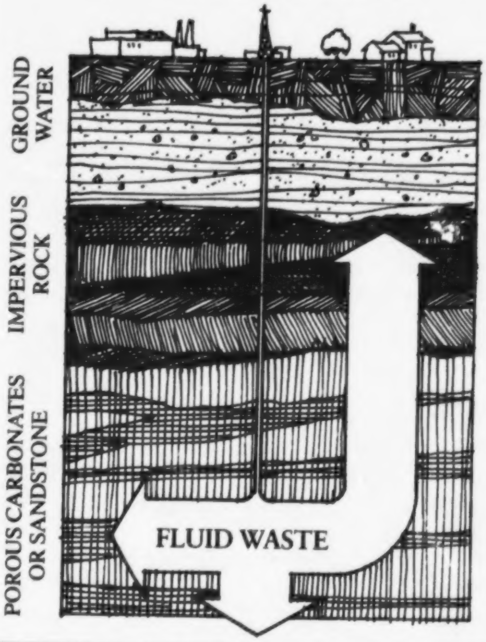
In support of proposed EPA Underground Injection Control (UIC) regulations, ORD was called on to answer some key technical questions concerning injection wells. What, for example, is the magnitude of the pressure build-up in these wells? How extensive and endangering is the "zone of influence" that this pressure exerts on nearby strata? What must be known to evaluate the environmental impact of an injection system? And how can such a system be monitored?

In 1979 ORD made considerable headway in answering these questions. Data concerning pressure build-up were amassed and studied. A case history of pollution problems arising from injection wells was compiled, and preliminary recommendations for extending existing methodology for predicting pressure build-up patterns were developed.



Deep well drilling rig

Growing out of this effort, over thirty equations were generated and evaluated in terms of their utility in calculating pressure increases around the salt water injection wells used by oil and gas producers.



POTENTIAL HAZARDS OF DEEP WELL INJECTION

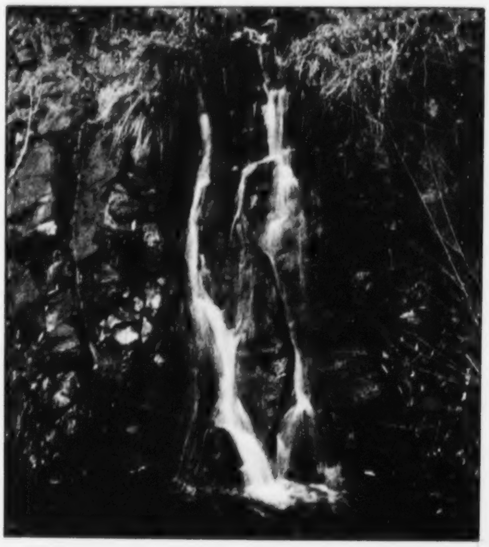
At the request of the Office of Water Supply, one equation was selected and applied to actual data from 115 injection wells in three Texas oil fields to determine their zone of endangering influence. A significant finding of this study was that to look at the zone of endangering influence of individual wells in an area where more than a single well exists does not provide a true picture of the pressure effects. Rather, such zones must be studied on a field or area basis, especially in areas where a common injection zone is being used.

The results of the ORD study will assist the EPA and the Office of Water Supply in their evaluation of proposed UIC regulations.

The Fate of Hazardous Pollutants

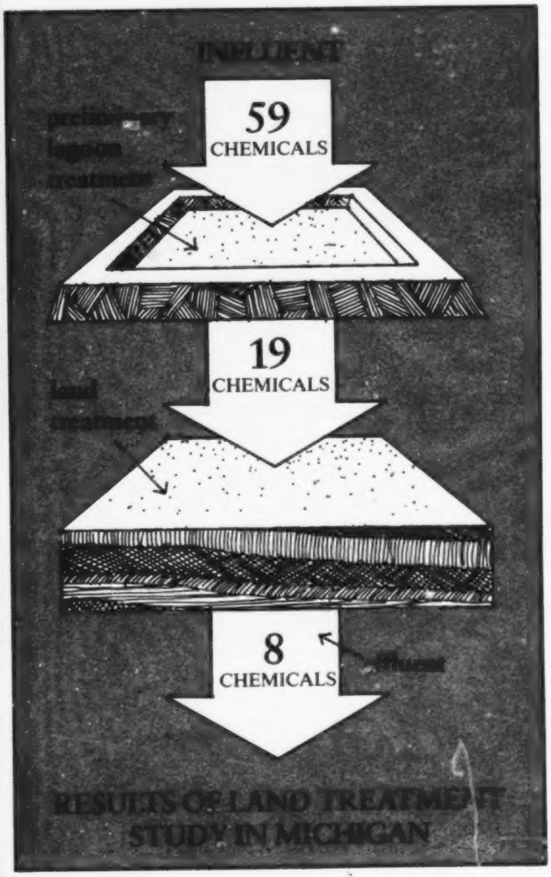
Movement of Organics in Groundwater. Groundwater is a source of drinking water for over half of the U.S. population, and over 96% of its rural population. The nation's groundwater supplies are being increasingly threatened, however, as more and more industries and municipalities channel wastes into the soil rather than into the air or surface waters. Hazards posed by such disposal procedures are difficult to monitor because an organic chemical's movement through the soil to groundwater supplies is a process that may take years and when and if a threat is manifest, and the groundwater is contaminated, its decontamination can, in turn, take decades, even centuries. For this reason ORD's groundwater research is directed toward pollution prevention and water quality protection, rather than toward restoration of groundwater supplies.

Once groundwater is contaminated, decontamination can take decades, even centuries



One recent study sought to evaluate the potential impact of a number of chlorinated organic chemicals on groundwater. Twenty chemicals, all reported in incidents of groundwater pollution, were studied in laboratory tests to determine how they are transformed and how quickly they travel through the soil profile. Forthcoming results will allow researchers to assess the consequences of chlorinating wastewater prior to its use in land applications and determine the groundwater impact from the use of chlorinated products such as septic tank cleaners.

A second study examined the transport and fate of a group of organic compounds in simulated high-rate land application waste treatment systems. Models describing the behavior of those pollutants are being developed, tested and refined, and the data generated may provide a first approximation of the effects on groundwater of applying treated wastewater to the land.


INFLUENT
preliminary lagoon treatment
59 CHEMICALS
19 CHEMICALS
land treatment
8 CHEMICALS
effluent
RESULTS OF LAND TREATMENT STUDY IN MICHIGAN

In a related study, ORD conducted a survey of toxic pollutants at a wastewater land-treatment plant in Michigan. Fifty-nine organic pollutants were identified in the influent wastewater. Following preliminary treatment in lagoons, 19 of these chemicals remained, although in diminished quantities. This wastewater was then applied to the soil and allowed to filter through a soil profile of 5-12 feet, after which it was collected. At that point, the water was found to contain only eight of the compounds in yet further reduced quantities.

While the study did indicate that the system was highly effective in reducing the presence and concentration of organics, it also pointed to the need for further research into the design and operation of land treatment systems.

In another research project, the movement of trace organics through an aquifer was studied to examine the possibilities of recharging groundwater supplies with treated wastewater. Results of this study indicated that certain compounds were biodegraded and adsorbed in the subsurface, while others persisted and posed a potential threat to the aquifer.

These studies are all elements in ORD's research program to protect the nation's groundwater supplies, and will contribute to the development of protocols for the use of physical models capable of predicting the transport and fate characteristics of pollutants in soil, subsoil, and groundwater environments.

Indicatory Fate Study. As a result of the 1976 consent decree requiring EPA to establish control for 65 priority pollutants found in industrial wastes and believed to pose major problems for the nation's waterways, in 1978 EPA's Effluent Guidelines Division requested that ORD study the fate of selected industrial pollutants as they passed through biological treatment systems.

Twelve industrial sites were chosen for the study, representing the waste make-up of six different industries. Samples were collected from the waste site influents, effluents, and from the residual or remaining sludge. The air was also sampled. Samples were analyzed using a variety of state-of-the-art tools and techniques.

Results of the study indicated that there was generally an increase in the concentrations of priority pollutants in the solid residuals of the plant's treatment systems, thus pointing clearly to the need for precautionary methods of sludge disposal. Results also demonstrated that in present biological systems certain organic compounds were particularly susceptible to release into the atmosphere. A third key finding in the ORD tests indicated that a number of new compounds were synthesized during the biological treatment process, particularly among specific organic compound groups.

The following ORD components contributed to the research described above:

- Office of Environmental Processes and Effects Research—Robert S. Kerr Environmental Research Laboratory, Ada
- Office of Monitoring and Technical Support—Environmental Monitoring Systems Laboratory, Las Vegas
- Office of Environmental Engineering and Technology—Municipal Environmental Research Laboratory, Cincinnati; Industrial Environmental Research Laboratories, Cincinnati and Edison

WATER QUALITY

New methods are developed to protect and restore lakes, streams and other water sources

When water quality is allowed to deteriorate, fish populations suffer and man's use of the water is restricted. At that point, there are but two alternatives — restore the water's quality, if it is still possible—or learn to live without. To avert facing the latter alternative, EPA sponsors a number of projects that seek to identify, monitor, and propose control measures for maintenance or improvement of the water quality throughout the United States. These following highlights are but a few of the many projects ongoing in water quality research.

Trout, Salmon and Sediments

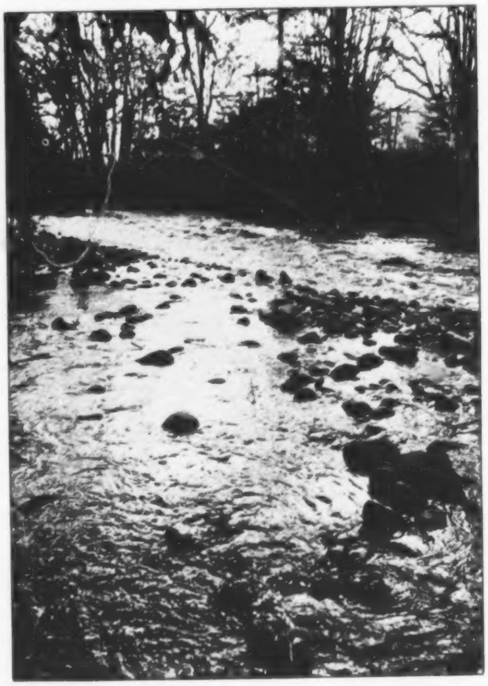
Unlike most other families of fish that spawn in freshwaters, Salmonids (trout and salmon) generally bury their eggs in the gravel of streams, then leave them unattended during incubation and emergence of the young fish, known as fry. Depending on the species and the water temperature, a period of two to five months elapses from the time Salmonid eggs are laid to the time the fry emerge from the gravel to the free-flowing water above.

During incubation, stream water must be able to percolate freely through the gravel to supply the eggs their necessary oxygen, and to carry off the metabolic wastes they produce. When development is complete and the fry emerge, they must have access to free flowing water. If, however, there is excessive sediment in the stream caused by improper logging practices, agricultural activities, urban construction or natural landslides, the composition of the stream bottom may be altered and the spaces between the gravel clogged. Incubation and emergence are thwarted, and the species threatened.

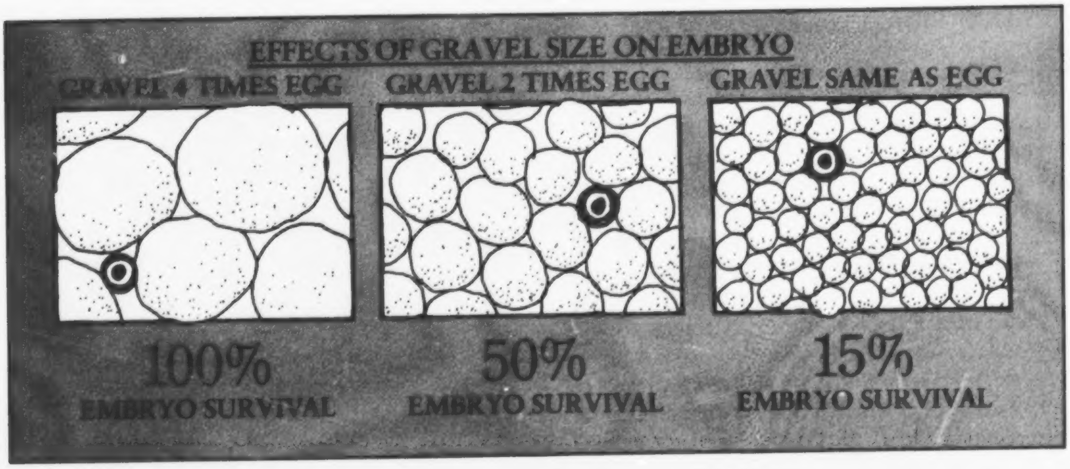
Excessive sediment alters the composition of the stream bottom

How extensive is this threat? What granular size of sediment is dangerous? How much sediment is deleterious? In 1979, EPA researchers, in collaboration with other scientists, developed a stream-bottom gravel and sediment monitoring method and a procedure for integrating the results of this gravel analysis to answer these questions. Using existing data, a formula was developed that relates the mean gravel diameter and mean egg diameter to the survival success of the young fish from incubation to emergence. For optimal survival, it was found that gravel diameter at the spawning site should be about four times egg diameter. This allows for both percolation and fry emergence. However, since sediment found on stream bottoms is generally finer than gravel, its presence inhibits both processes and diminishes the chances for successful reproduction. If, for example, the mean gravel and sediment diameter is only twice the egg diameter, according to the formula survival will average only about 50%. Or if both diameters are equal, as may be the case in streams with heavy sediment, only a 15% chance of survival remains.

While spawning failure is not uncommon and exists in streams untouched by man, it is expected that this stream-bed predictive and analytical formula will allow for a better estimation of those spawning changes induced by human activity. Additionally, this formula should prove a valuable predictive tool for use by enforcement programs to protect our trout and salmon populations.

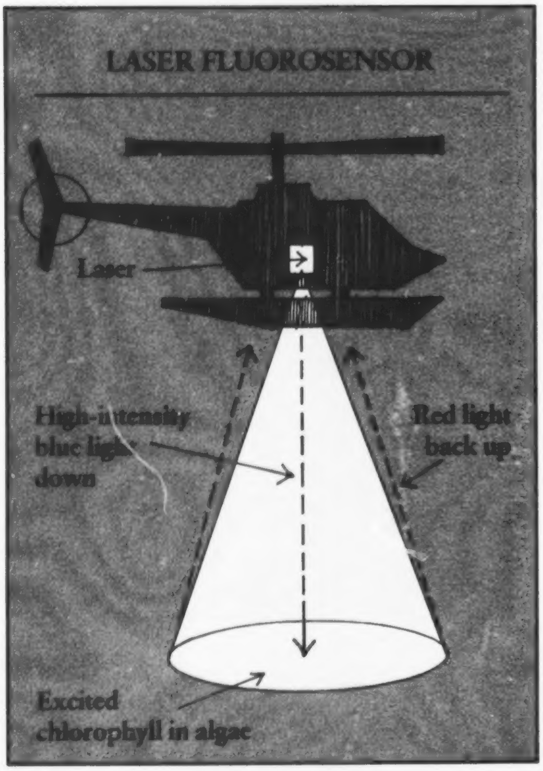


Sediment in spawning streams can seriously affect the survival chances of salmon



Laser Fluorosensor

A high density of planktonic algae in surface waters for extended periods frequently indicates high levels of nutrient pollution from waste effluents or agricultural land runoff or percolation. High productivity of algae populations can generate foul-smelling and even toxic water conditions after phytoplankton die-off, along with severe depletions in water oxygen levels, which in turn cause an adverse effect on fish populations. Conversely, excessively low levels of algae may suggest presence of substances toxic not only to the algae but to higher life forms.



Over the last 3 years, ORD has developed and tested an airborne sensing device called a laser fluorosensor that can be used to map the distribution of surface water chlorophyll, a key constituent of planktonic algae. Traditional monitoring of chlorophyll in planktonic algae requires manual sampling from a number of lake locations and wet chemical analysis. Such monitoring is slow, labor intensive, and by its nature, spotty. However, using ORD's laser fluorosensor, it has been demonstrated that the equivalent of tens of thousands of chlorophyll sample estimates can be made in one hour. Such data in conjunction with one or two on-site reference samples is then processed and mapped to predict the density of chlorophyll concentration over the entire water surface.

The fluorosensor consists of a laser transmitter that is joined to a telescope receiver. It is mounted on an airplane or helicopter and flown at a height of several hundred meters above the water's surface. The laser transmits short-duration, high-intensity pulses of blue light, which in turn excite the chlorophyll in the algae to emit pulses of red fluorescent light. This red emission is collected by the telescope and converted into an electrical signal, which is recorded on magnetic tape for later analysis and comparison to reference samples.

ORD researchers extensively tested and evaluated the prototype laser fluorosensor in 1979. Chlorophyll profiles of polluted regions of Nevada's Lake Mead were produced.

Forestry Management

Nearly one-third of the U.S. is covered by forests. Although much of this forest land is set aside as wilderness, a large portion is subject to forestry activity to supply timber for a variety of uses. These lands, however, are far more than just a source for timber; they also serve as watersheds to catch and hold rainfall and snowmelt for release into streams and rivers. The streams, in turn, are spawning areas for fish, provide water for many municipalities, and offer countless recreational opportunities, all of which require high levels of water quality. This raises the question then, can water quality be maintained in the face of intensive forestry management activities like logging and other development?

A five-year joint research effort involving ORD, the U.S. Forest Service, and several universities has been studying the integration of water

Logging roads can cause damaging erosion in forest lands

Forest slope after clearcutting

quality control with overall forestry management. The major objectives of this work are to identify water quality problems and the control techniques to mitigate them, and to define cost-effective management strategies that embrace both the needs of the timber industry and those of the environment.

Some important results were realized in 1979. The major water quality problem associated with timber production was found to be the heavy loading of waterways with sediment resulting from the disturbance of land in upland forests. Secondary problems were found to result from the improper use of pesticides and fertilizers and the disposal of liquid and solid wastes. Control techniques evaluated included the planting of vegetation to reduce erosion, building access roads in a manner that minimizes erosion, constructing sediment basins to allow the sediment to settle prior to release of runoff water into stream channels, and halting road traffic during periods of high runoff.

Research in 1979 into cost-effective management strategies produced a technique for estimating changes in water quality from forestry activities through the use of computer-based models. The processes modeled were highly complex and ranged from snowmelt reactions in higher mountain regions to sediment deposition and movement in streams draining into coastal areas. In addition, a "goal programming" approach was developed to aid in decision-making when environmental and timber production needs are in conflict.

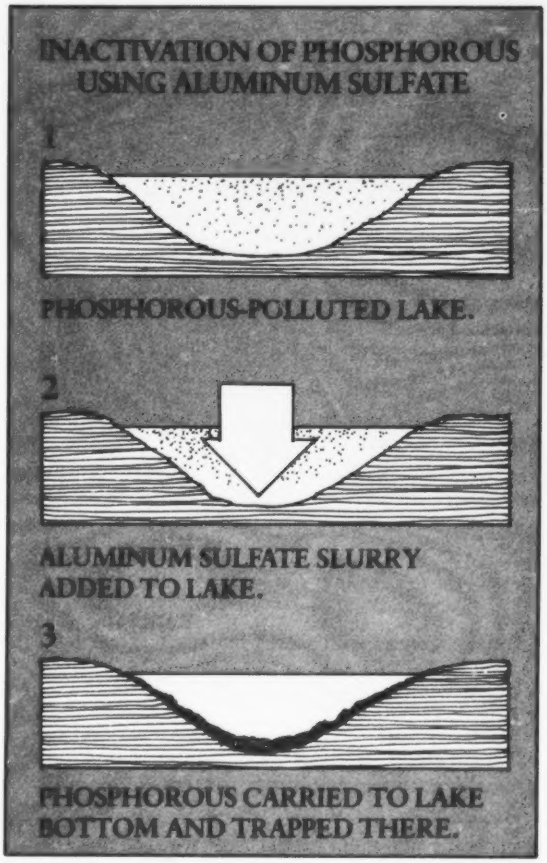
Lake Restoration

EPA's Office of Water Planning and Standards has been charged by Congress to oversee the protection and improvement of the water quality in the nation's freshwater lakes. EPA's Lake Restoration Evaluation Program provides direct assistance in achieving this goal by helping to determine the effectiveness of water pollution controls and lake restoration techniques on different lakes. Among the methods of restoration used historically are (1) those that treat or modify the water inputs to a lake, (2) those that are performed in-lake such as dredging or bottom sealing, and (3) those that are directed at treating symptoms rather than the problems at their source. Despite the vari-

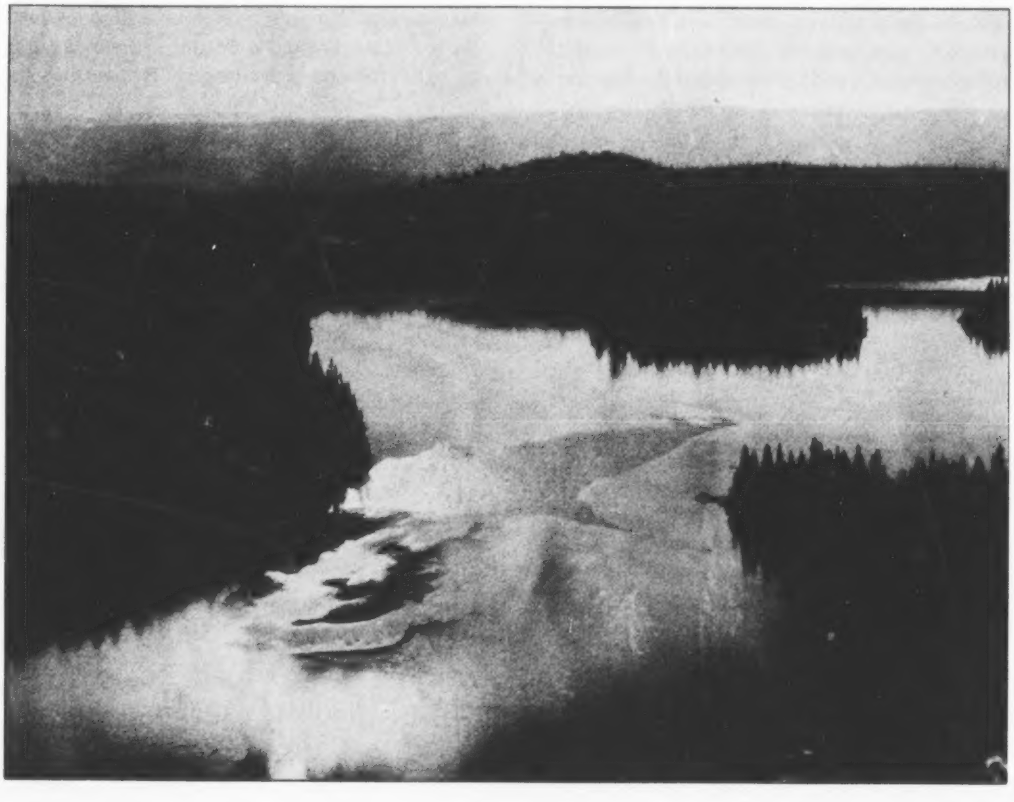
ety of treatment methods, however, the goal of most restoration projects is to limit the amount of biologically-active phosphorous in the water either directly or indirectly. Phosphorous, a common ingredient in most household laundry soaps, stimulates explosive growth of algae, particularly noxious blue-green algae.

In 1979, new projects were identified, lakes to be evaluated were classified, experiments were designed, and evaluation techniques were refined. Economic and social studies were also instituted where appropriate to focus on human concerns, actions, and the consequences of lake restoration. Who, for example, will benefit from lake restoration? Who will pay? And, is it worth it in dollars and cents? Improved procedures for making these socioeconomic assessments are evolving as research continues.

While most pollutant effects on lakes are subtle, occurring over a long period of time, so too are restoration effects. One treatment, however—the in-lake inactivation of phosphorous with an aluminum salt—often yields immediate and dramatic results. Here a slurry of aluminum sulfate (alum) and/or sodium aluminate is added directly to a lake. As these salts settle to the bottom they carry suspended solid and precipitated soluble nutrient matter (the phosphorous) with them, effectively stripping the water column of the phosphorous and solids and creating a partial seal at the sediment/


INACTIVATION OF PHOSPHOROUS
USING ALUMINUM SULFATE
1
PHOSPHOROUS-POLLUTED LAKE.
2
ALUMINUM SULFATE SLURRY ADDED TO LAKE.
3
PHOSPHOROUS CARRIED TO LAKE BOTTOM AND TRAPPED THERE.

Little Trout Lake in northwestern Minnesota

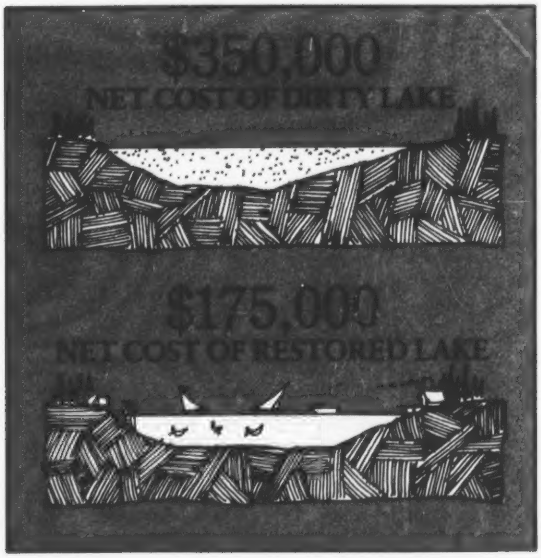


water interface to prevent their re-entry into the overlying water. The effects of this technique are being evaluated at lakes in Wisconsin and Washington. To date, short-term response of lakes to this treatment has been exceptional. All indicators point to reductions in total phosphorous, and other nutrients that feed the algae biomass that can choke a lake. Two- to three-fold increases in water clarity were also observed.

Short-term response of lakes has been exceptional

A second treatment that produces significant short-term water quality changes is the dilution of a lake's dissolved solids, a procedure that involves pumping large amounts of better quality water into the lake being restored. When a series of evaluations were made of a lake in Washington following its dilution by Columbia River water, a more than 50% reduction in phosphorous was observed and water clarity considerably improved. Blue-green algae populations were also reduced.

With both of these techniques, however, only short-term effects have been measured. Longer range monitoring will provide researchers with a more accurate sense of lake restoration potential—both ecologically and economically.


$350,000
NET COST OF DIRTY LAKE
$175,000
NET COST OF RESTORED LAKE

Rocky shoreline of Embla Lake, northern Minnesota

Also, recently developed under the auspices of the Lake Restoration Program is a procedure that will enable planners to more clearly determine the dollar trade-offs involved in the maintenance of water quality levels. A 1979 application of the procedure was built around a lake undergoing degradation caused by stormwater runoff. Here it was estimated that the decline of the lake's water quality would lead to a decrease of 27,000 annual recreational visits representing a dollar value of approximately $40,000 each year. The present value of these visits over a twenty-year period, at 10% interest, would yield a loss of $350,000 to the area. This loss could be avoided, according to study figures, by an expenditure of $175,000 for a stormwater diversion system, which would result in a net savings of $175,000. In this example the cost of restoration clearly is less than the long-term losses that would be incurred were lake degradation allowed to continue. It is expected that this financial cost trade-off procedure will enhance lake restoration decision-making in the future.

The following ORD components contributed to the research described above:

- Office of Monitoring and Technical Support—Environmental Monitoring Systems Laboratory, Las Vegas
- Office of Environmental Processes and Effects Research—Environmental Research Laboratories, Corvallis and Athens

THE COASTAL ENVIRONMENT

ORD studies assist the effort to protect our fragile coastlines from onshore and offshore threats

The President's Message

Over half of the U.S. population lives in a 50-mile wide strip of land along the nation's coasts. Nearly one-half of the U.S. multibillion dollar fishing industry depends directly on near-shore waters. The coast provides a home for heavy and light industry and a prosperous recreation industry as well. And billions of dollars worth of goods arrive and leave from our coastal ports annually.

The coast is a land under pressure. More than 50% of the Atlantic shellfish beds were closed in 1979 due to pesticide, oil, and sewage contamination. Over the years, man has altered two-thirds of our offshore barrier islands, in some cases destroying these natural storm buffers. And land available for recreation is at an all-time low.

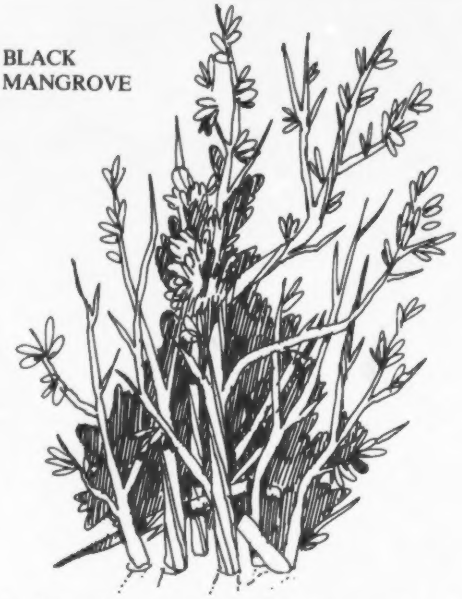
In August 1979, responding to the challenge of protecting our coast, President Carter endorsed 1980 as the ''Year of the Coast'' and outlined a three-point initiative to continue and improve our resource protection policy.

First, the Executive Branch will submit legislation to Congress to reauthorize federal assistance for state coastal zone management programs under the Coastal Zone Management Act of 1972 (CZMA) that will guarantee each state a total of five years of federal assistance at current levels after a state management program is approved and before federal support is gradually phased down. Second, new amendments will be recommended by CZMA which will establish a national coastal policy. The recommended amendments will provide for protecting the coastal areas and wildlife, managing coastal development, siting new coastal development under guidelines, coordinating government decisions about the use of our coasts, and preserving and restoring valuable coastal areas. And third, the Secretary of Commerce will be directed to conduct a review of federal programs that affect coastal resources to determine any conflicts with CZMA. This will provide a basis for actions necessary to improve such federal programs and for the development of any necessary additional information. ORD research data will help support the decisions that will be made to implement the President's objectives.

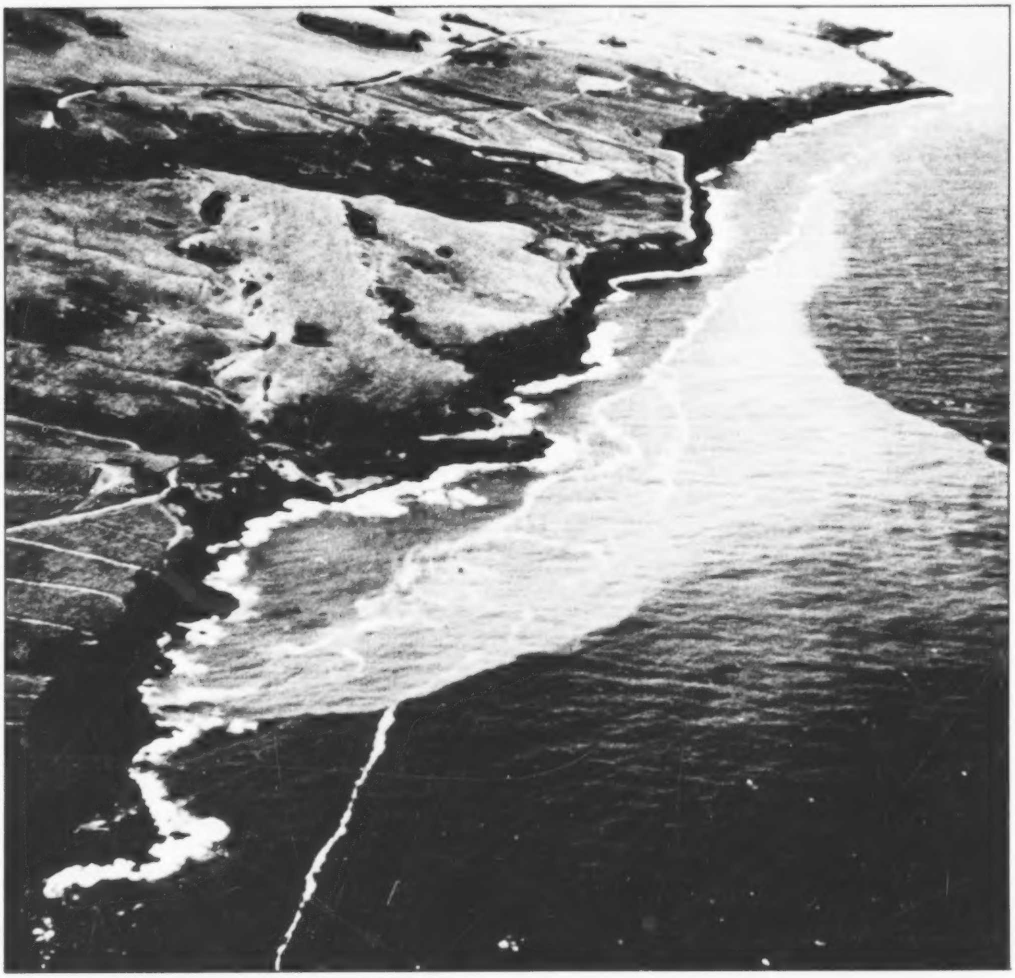
Wetlands

In 1979, EPA research into marsh or wetland ecosystems — among the most productive ecosystems in the world — was highlighted by a number of studies. In Florida, where developers are proposing destruction of stands of black mangrove trees, scientists funded by EPA have been at work to determine whether these marsh trees are essential in the production of food supplies for coastal ecosystems. Preliminary results indicate that the mangroves are a significant link in the estuarine food chain and that their destruction would alter the region's ecosystem.

In a second study, northwest coastal wetlands were investigated to determine the productivity of selected marshes and the biological and physical mechanisms that control it. Specific species of marsh plants were studied and their productivity rates established. It was found that certain species are far more productive than others and that productivity rates vary considerably. From this work, a handbook for estimating primary productivity was prepared. This handbook will enable informed decisions to be made in estimating the effects of development or other modification on the productivity of wetlands ecosystems.


BLACK MANGROVE

Other wetland studies in 1979 included projects to explore the relationship between plant species distribution and soil parameters that relate to species growth and adaptability and a project to test for the slow deterioration of wetland plants in the presence of low concentrations of subtle toxic materials. It was found that the stresses put on these marsh plants by toxics, such as heavy metals, could be used as indicators of the movement of the toxic materials through the marsh ecosystem.



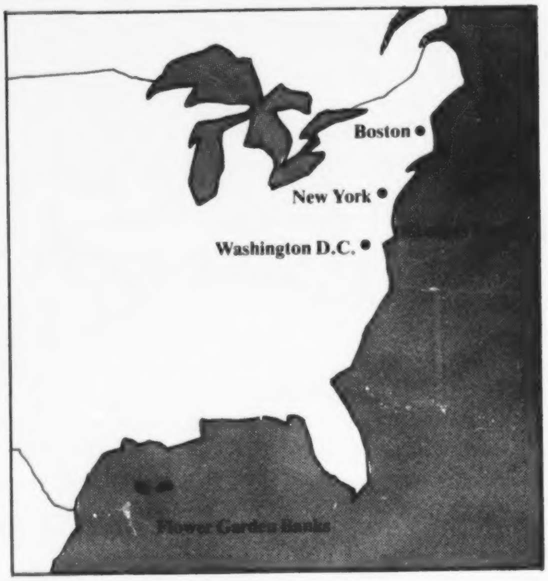
Ocean outfall

Ocean Outfalls

Precisely what level of treatment is needed to protect the marine environment from municipal wastewater discharge in a given location? This is the question that confronts EPA today when municipalities request a permit that modifies the uniform secondary treatment requirements outlined by the 1972 amendments to the Federal Water Pollution Control Act. Ongoing ORD field monitoring and laboratory studies assure informed decisions.

Following passage of the 1972 amendments, which defined secondary treatment in terms of discharge levels of acidity and fecal coliform and required the removal of biochemical oxygen-demanding material and suspended solids, the EPA established a task force to determine if, indeed, secondary treatment was necessary in all instances. Based partly on task force findings and partly on substantial information provided by large municipalities, Congress, in 1977, granted EPA the authority to issue to publicly owned treatment works permits which allowed wastewater that had not received secondary treatment to be discharged through ocean outfalls to specified marine waters. However, these exempted plants were still required to meet other specific criteria of the Act, and Congress emphasized that issuance of the permits was temporary—an experiment to be closely monitored to assure the ecological integrity of the marine environment.

ORD was charged with defining data needs and helping interpret data collected for decisions on whether or not to issue permits. ORD was to also help interpret data from monitoring programs once permits were issued. It was already known that some nearshore coastal environments were very sensitive and delicately balanced so that a high degree of treatment (more extensive than secondary) would be required if outfalls were to be allowed, while others were more resilient, so less-than-conventional secondary treatment would be adequate. But not enough was known about the specific relationships between sewage quality, degree of treatment, and marine ecosystem effects. One study underway in 1979 to examine this problem is being conducted in Miami, Florida. The study is designed to determine precisely the kind of wastewater treatment needed to protect the corals, sponges, and fish found in nearshore waters of southeast Florida. Another study in Hawaii has shown the recovery of Kaneohe Bay after a secondary treatment plant replaced a sewage outfall. Other studies and future work will further explore the delicate balances in marine ecosystems that receive wastewater discharges.



Offshore Drilling

The intensive search for oil and gas in the United States has led to increased offshore drilling for these valuable resources. As part of the normal drilling operations from offshore oil drilling platforms, chemicals are routinely discharged into the marine environment. With the increase in offshore drilling, greater volumes of chemicals will be dumped into coastal waters. EPA has the responsibility to issue and enforce discharge permits that ensure that the platform/drilling rig operators meet the goals of the Clean Water Act and the Ocean Dumping Act. However, current environmental effects data are inadequate to scientifically support EPA's permit responsibilities to deal with the increased chemical loads that are predicted. Therefore, ORD is sponsoring research to determine the potential environmental effects of chemicals normally discharged in offshore oil and gas drilling. The research will focus on drilling sites in the Georges Bank fishing ground off New England and at the coral reefs, known as the "Flower Garden Banks," off the Texas coast. These research results, which should be applicable to other coastal regions as well, will assist all the EPA regional offices with coasts as part of their jurisdiction.

When an offshore well is being drilled, a special mixture of clay, water, and chemicals is essential to the operation. As this mud is pumped down into the drilled hole through the drillpipe and the drillbit, it cools the rapidly rotating bit, lubricates the drilling string (steel pipe attaching the bit to the drill rig) as it turns in the wellbore, and carries rock cuttings to the surface. The mud also serves as a plaster to prevent the surrounding rock from crumbling or collapsing into the wellbore and provides the hydrostatic head necessary to control downhole pressures and to keep extraneous fluids (such as the seawater) from entering the wellbore.

With the increase in offshore drilling, greater volumes of chemicals will be dumped into coastal waters

The chemicals are added to drilling mud to enhance the mud's ability to perform its many tasks. These chemicals can range from bactericides, calcium removers, corrosion inhibitors, defoamers and emulsifiers to filtrate reducers, shale-control inhibitors, thinners, dispersants, and weighting

Offshore drilling rig

agents. From an environmental point of view, the question of concern is "at what levels are these chemicals toxic to the surrounding marine ecosystem?" And, therefore, when EPA issues a discharge permit, the question is "what is the maximum toxicant concentration allowable that will still protect man and the sea life?"

In 1979, EPA reported research results to help answer these questions. The project was located on a U.S. Navy offshore research platform 12 miles off the coast of the Florida panhandle in the Gulf of Mexico. With close cooperation from personnel aboard an Amoco drilling rig only 20 miles away, ORD scientists were able to simulate realistic drilling conditions. Small marine animals (shrimp and shellfish), flora, and coral samples were collected from the sea floor and placed in specially prepared tanks both on board the platform and at EPA's laboratory at Gulf Breeze, Florida. Unfiltered seawater was pumped into the tanks at both sites as were various samples of drilling fluids from the nearby Amoco rig to test the effects of the fluids on the marine life samples.

The research findings from the project and from available scientific literature showed that:

- Drilling fluid is ten times more toxic than industrial effluents such as untreated wastes from oil refineries or pulp mills.
- Carcinogens are discharged during drilling operations.
- Drilling compounds thought to be "insoluble" and therefore "biologically unavailable" are, instead, actively taken up by marine organisms.

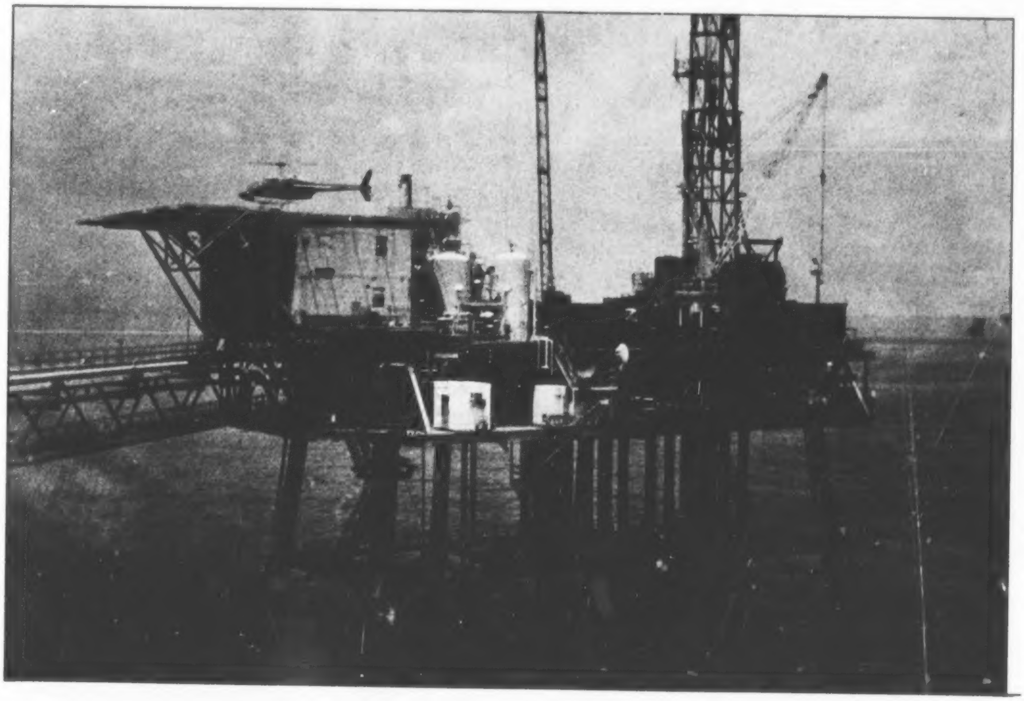
- Chemicals normally discharged are capable of accumulating in marine organisms.
- Chemicals discharged during drilling persist for years in the sea bottom sediments.
- A wide variety of organisms that normally live on the sea floor cannot grow on sediments contaminated by drilling fluids.
- Effects of chemicals on coral may be delayed for a year before they can be observed.

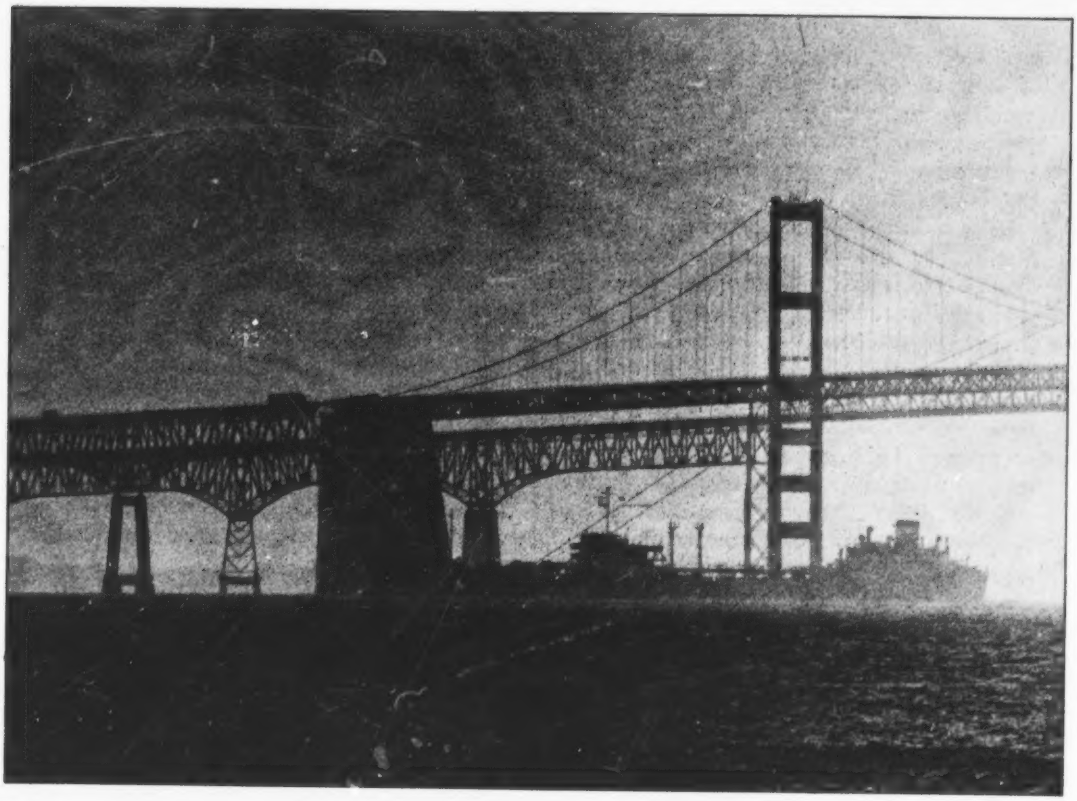
These findings do not answer all the environmental questions about the effects of offshore oil and gas drilling; the effects of different chemical mixtures on different marine species still need to be determined to fulfill the data needs of future discharge permits.

The following ORD components contributed to the research described above:

- Office of Environmental Processes and Effects Research—Environmental Research Laboratories, Corvallis and Gulf Breeze

Offshore drilling platform





Information gathered by ORD helps to clarify the options available in the preservation of Chesapeake Bay

Chesapeake Bay is by far the largest and most complex of the 850 estuaries dotting the coastline of the United States. It is 190 miles long and has 8000 miles of shoreline. It drains a watershed of 65,000 square miles, encompassing parts of six states. It supports a recreation industry estimated at $200 million a year. There are 80,000 licensed hunters and fishermen in the Bay area, and upwards of 200,000 licensed pleasure boats. More than 100 million tons of cargo are carried up and down Bay channels annually, representing $4 billion worth of goods. In a good year, the Bay produces an enormous seafood harvest representing a major share of the entire East Coast catch.

This very prosperity and wealth of resources, however, creates problems of significant magnitude as various interests seek to mold the Bay area to their particular version of the future. As these proponents of industrial use, commercial development, sportfishing, land use, recreational development, commercial shipping and a host of other interests come into conflict, key questions inevitably arise, questions surrounding the environmental costs and consequences of the actions that will ultimately be taken. Unfortunately, the data to answer these questions are in short supply, which is the reason for ORD's aggressive effort to collect, catalogue, analyze and distribute as much scientific information about the Bay's environmental future as possible.

In 1975, Congress authorized $25 million for a five-year program to begin in 1976 that would study the Bay area's environment with the ultimate goal of determining management options for the Chesapeake environment. The funds are currently supporting the research efforts of more than 40 principal investigators from over 30 institutions and organizations working under the guidance of EPA project officers.

Since its inception, the Chesapeake Bay Program has attempted to foster decision-making at the local level in political bodies that represent the people who live in the Bay area or who make their livelihood from the Bay's resources. The program has thus carefully avoided any hint of bureaucratic control over land developers, industries and businesses who now put environmental pressures on the Bay. Furthermore, the program has attempted to complement, rather than replace or interfere with, current environmental studies being done by other agencies, institutions or citizens' groups.

Overall, the program is intended to:

- sort out the array of programs, laws, research projects, and citizens' efforts;
- coordinate and help evaluate scientific work going on;
- help fill gaps where more information is needed to most effectively manage the future of the Bay.

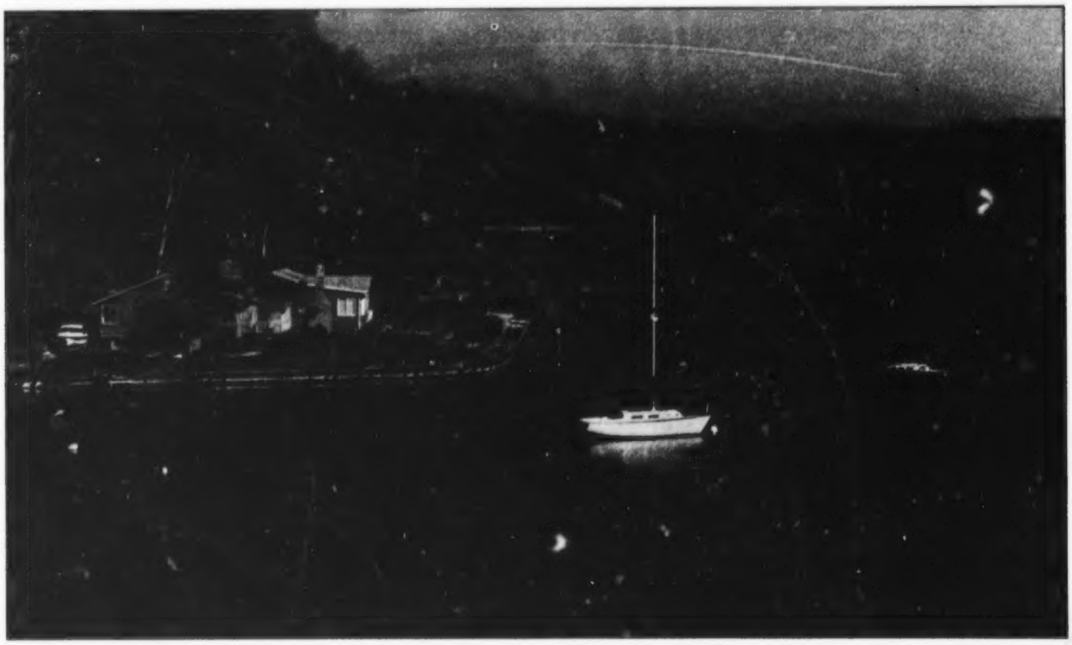
The program's goal is to provide the people with straightforward facts, alternatives, and realistic costs, in order that well-informed decisions about the Bay area's environmental future can be made. If people in the area, for example, opt for maintaining the status quo, the results of the study will tell them *this* is what maintaining the status quo means environmentally and *these* will be the costs sustained. If, on the other hand, the choice is to improve environmental quality then *this* is what it will cost and *these* are the benefits that can be expected.

The program is currently well underway. An EPA local office has been established in Annapolis, Maryland and is staffed with scientific experts and research managers. In Bay waters touching Maryland and Virginia, researchers have collected samples that were then catalogued and stored for future reference. A toxics program is establishing baseline data for monitoring water, sediments, and aquatic organisms for toxic pollutants. Currently, sediment samples are being taken from more than 6000 sites to test for toxics and other materials. Potential sources of the toxics were assessed, and an inventory was made of some 100 industrial dischargers and 400 discharge pipes.

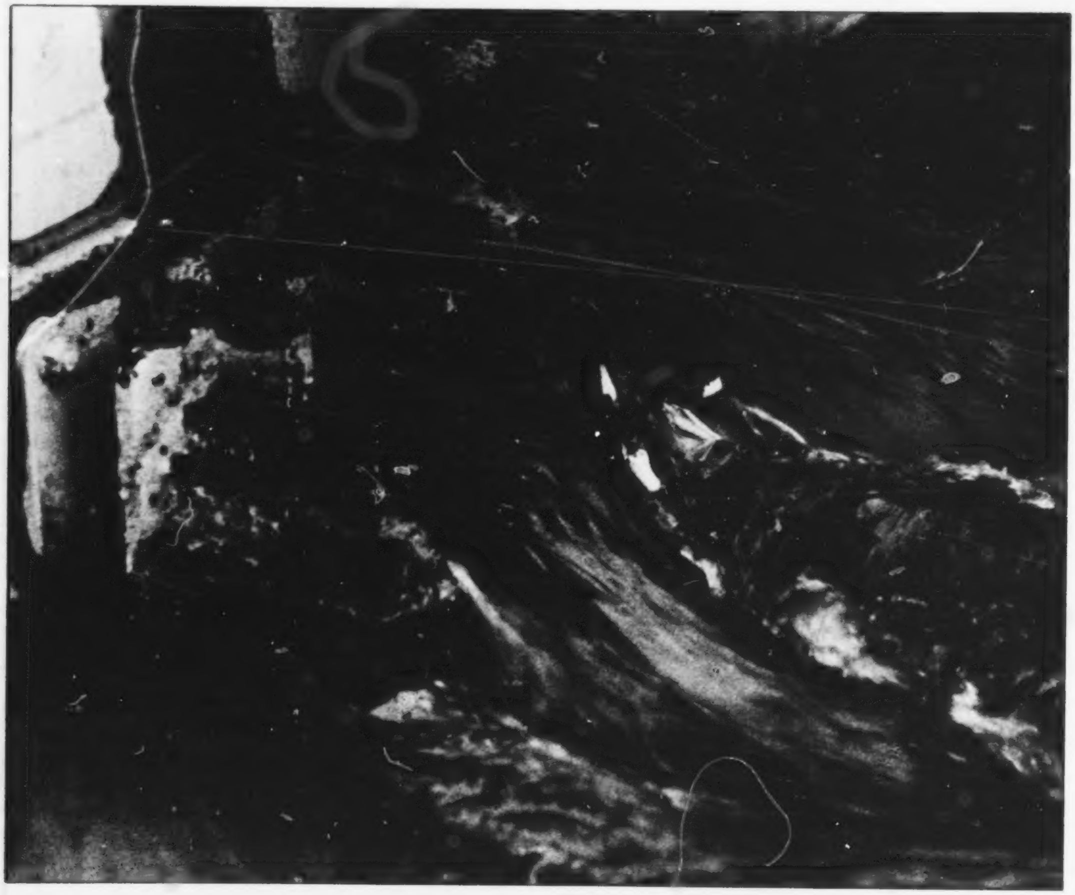
It is expected that the EPA Chesapeake Bay fact-finding program will provide a sound basis on which to determine the environmental future of what is today, and hopefully will remain, a vital, thriving area.

The following ORD components contributed to the research described above:

- Office of Research and Development, Region III, Philadelphia



Chesapeake Bay supports a recreation industry estimated at $200 million a year



ORD researchers analyze cost-effective methods of improving existing wastewater treatment facilities

A major challenge confronting ORD's wastewater program is finding ways to upgrade performance of existing municipal wastewater plants without requiring major modifications. To this end issues such as treatment plant reliability, plant management and staff education, and optimum system design and operation are being evaluated and their relative impact on performance measured.

A second challenge faced by the program involves the environmentally sound disinfection of wastewater to facilitate its reuse in industry and agriculture. Here, as water supplies dwindle, cost effective alternatives must be designed, evaluated, and implemented. Other significant issues addressed in 1979 research include evaluation of the health impact of aerosols derived from wastewater treatment plants, the treatment of combined sewer overflows by magnetic separation of solids, and methods for wastewater reclamation and reuse.

Treatment Plant Operation and Design Program

Composite correction — Under ORD's Treatment Plant Operation and Design Program, a Composite Correction Program (CCP) for treatment plants was developed in 1979 as a result of a 3½-year survey which revealed a number of causes of poor plant performance. During the survey, 103 plants were comprehensively evaluated and performance-limiting factors were examined and then ranked in order of severity of impact. Of the seventy factors ranked, the sixteen leading causes of poor plant performance involved either operational problems (i.e., inadequate application of concepts and testing for process control), improper technical guidance, or plant design. Overall poor plant performance, however, was never the result of only one of these limiting factors, but always a combination of them, and often the limiting factors were interrelated.

The purpose of this comprehensive plant performance evaluation and the CCP was to identify all performance limiting factors with the goal of eliminating as many of them as possible, stopping short of any major plant redesign and construction. In 1979, this was pursued by the implementation of the recommendations contained in the comprehensive CCP evaluation reports.

Initial results were gratifying. At those plants where CCP corrections were implemented, significantly improved performance was demonstrated, often simply by changing operating procedures or making low-cost modifications in plant design.

At the time of the initial evaluation it was found that only 37 (36%) of the 103 plants evaluated were meeting National Pollution Discharge Elimination System (NPDES) standards with any consistency. It was then estimated that by implementing CCP recommendations, an additional 51 plants could improve levels of performance without major upgrading of existing facilities, thereby increasing compliance from 36% to 85%.

Improving plant reliability — The reliability of a treatment plant can be measured in a number of ways. NPDES standards require that specific effluent quality parameters are not exceeded over a certain period of time. A plant's reliability (as related to effluent quality) is the probability that such standards are met. Thus, a plant 95% reliable

Wastewater settling tanks

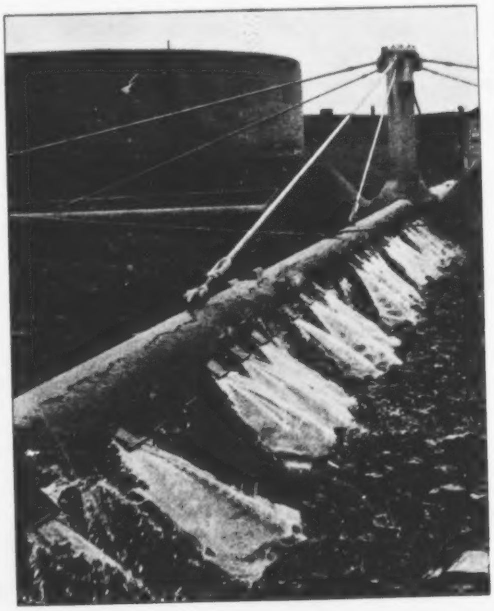
is one that meets or exceeds standards 95% of the time; or a plant may be 82% reliable in meeting standards for biochemical oxygen demand (BOD), while 92% reliable in meeting standards for total suspended solids (TSS). Reliability is also a measure of a plant's overall capability to perform its functions and includes an examination of specific design, operation, and mechanical factors.

Recent research defined the existing levels of reliability of treatment plants for a variety of biological systems. Computer modeling was used to develop reliability-based design procedures that factor in the effects of influent toxic materials and the impacts of treatment by-products on overall performance and cost. Also, a critical analysis was completed that determined which mechanical components have the most drastic and immediate impact on effluent quality when a failure occurs.

Land treatment of wastewater

Improving plant design — A comprehensive matrix was developed that identified more than 1000 design deficiencies and correlated them to correction modules. These modules recommend correction methods for existing facilities and provide design guidance necessary to circumvent such deficiencies in new or upgraded plants.

In 1979, the *Design Information and Guidance* series of informational documents was initiated to analyze existing design practices and present design criteria that reflect a consensus of opinion. Among the topics examined in 1979 were peak flows and their impact on plant process designs and the adequacy of current design practices for assessing the performance of a relatively new secondary treatment process for wastewater known as the Rotating Biological Contactors (RBC).

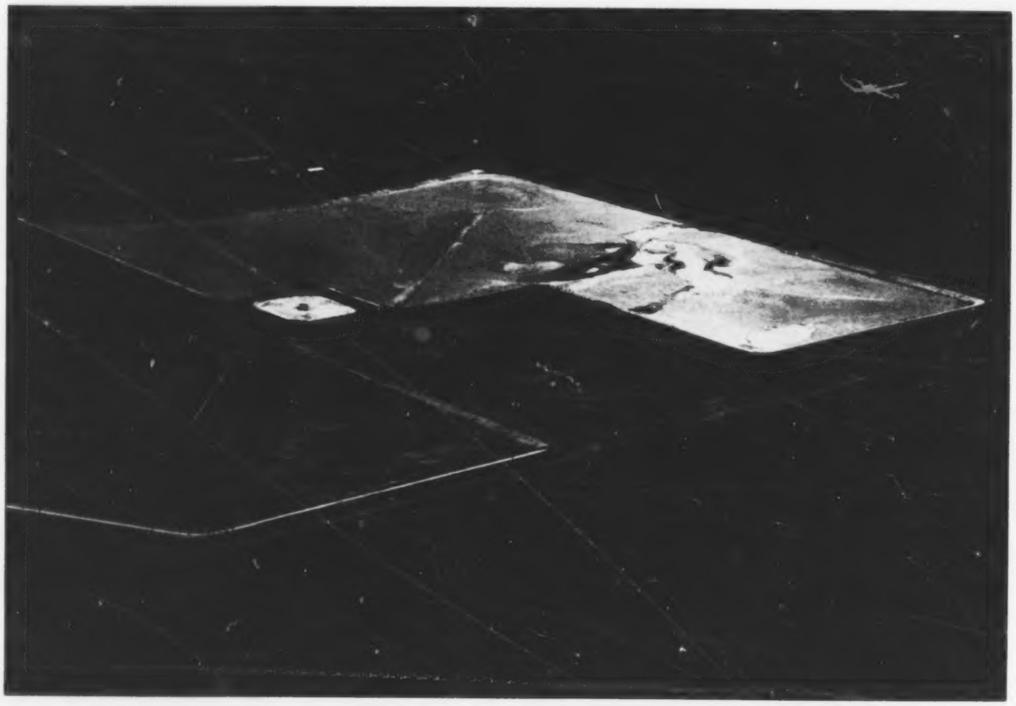


Wastewater used to filter solid waste in Oklahoma

Improving unit process and systems management — A comprehensive computerized cost and performance data base was established that contains design, performance and operating, and maintenance information from 270 plants, as well as energy demands and cost effectiveness figures for both conventional and alternative wastewater treatment technologies. The data base is being enlarged, and is available to interested municipalities.

Recent research in instrumentation and automation of treatment plants has emphasized the development of control strategies for the activated sludge process and for selected sludge handling and stabilization techniques. 1979 highlights include production of a design handbook to aid in the development of cost-effective systems. A series of pilot-scale and field evaluations of automated process sludge control strategies proved such ideas to be cost effective. The strategies included sludge modification, aeration methods, new equipment, and dissolved oxygen control methods. Also, a method was developed to determine the optimum dose of chemicals necessary for sludge conditioning prior to dewatering for sludge stabilization.

Studies in 1979 on centralized management for a number of treatment plants indicated the potential for cost savings and improved performance. Savings may also be realized in the collective operation of groups of small treatment plants through the pooling of resources and use of microprocessors, automated monitoring, and remote telemetry. Work is currently underway that will further describe and evaluate the concepts and characteristics of centralized management as they relate to specific plant engineering approaches.



Wastewater lagoon in Oklahoma

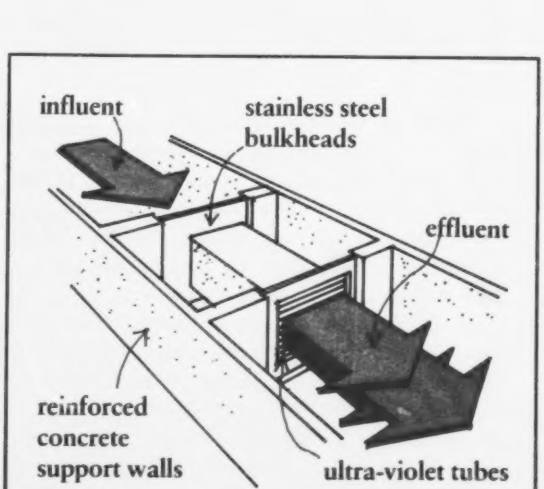
Ultraviolet Light

The use of ultraviolet light in the disinfection of sewage is seen as an environmentally attractive alternative to chlorination. In a recently-completed study at the Northwest Bergen County Water Pollution Control Plant in Waldwick, New Jersey, a prototype ultraviolet disinfection unit demonstrated its cost effectiveness and operated for 15 months without a major equipment malfunction. During the time of operation, the fecal coliform levels in the treated stream consistently conformed to state standards, and the unit proved capable of disinfecting the entire treatment flow of the plant.

The unit consisted of a number of tube-like ultraviolet lamps placed horizontally in a stainless steel bulkhead measuring 3 x 3 x 6 ft. The effluent was gravity fed into the bulkhead where it passed between the lamps. The thickness of the stream of effluent was determined by the spacing of the lamps. This particular unit employed the "thin film" design with a liquid thickness of approximately ¼ in. The unit was mechanically cleaned by a wiper mechanism.

Additional experiments established that ultraviolet light causes no change in the nonvolatile organic components of the effluent. The possibility that bacteria damaged by ultraviolet light can repair themselves when exposed to natural light was also studied and found to be true to some extent, particularly in the summer months. Work is planned to minimize this *photoreactivation* effect.

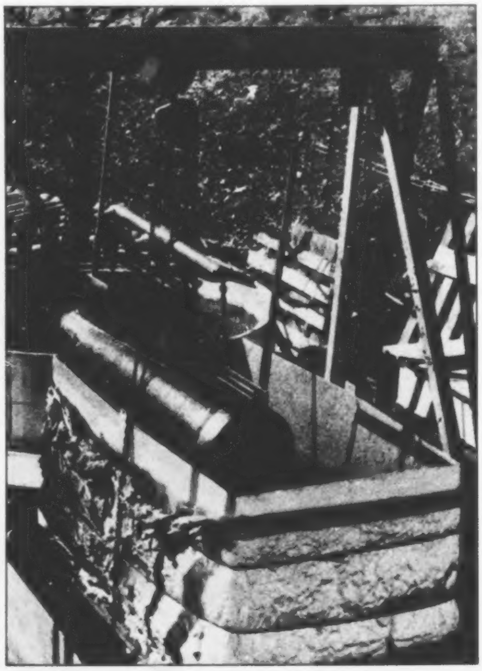
While the cost of ultraviolet disinfection in the Northwest Bergen County study was competitive with that of chlorination, the effluent was of better than average quality. A second generation study will determine the effectiveness of similar systems on a broad spectrum of effluents. Also, thin film designs will be compared with thicker film designs to establish optimum cost/benefit performance characteristics. It is expected that the results of this



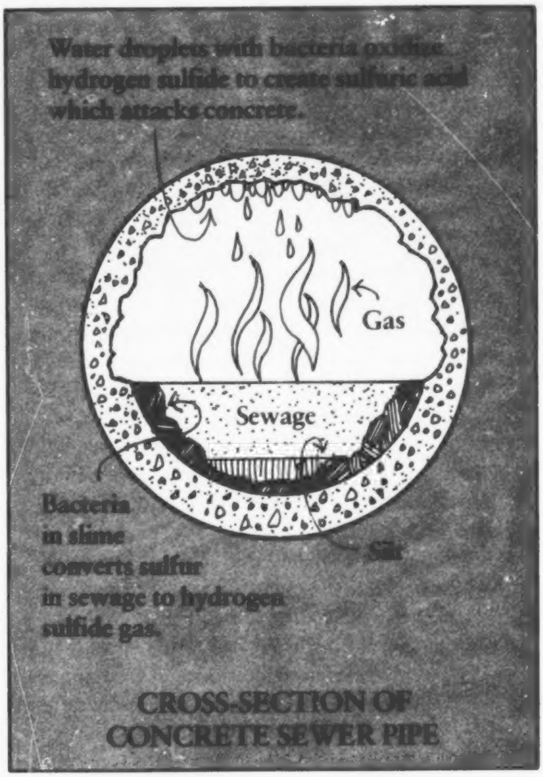
ULTRAVIOLET DISINFECTION UNIT INSTALLATION study along with other related ORD activities will provide the information necessary to begin implementation of ultraviolet light disinfection at municipal facilities.

Concrete Pipe

Concrete pipe is the most popular and most widely used in sewer construction. It is, however, susceptible to corrosion which occurs above the liquid level in the pipe and is largely caused by sulfates in sewage that are reduced to sulfuric acid, which undermines the integrity of the pipe's interior. Such corrosion results in leakage, infiltration, overflows, the bypassing and overloading of treatment facilities, and ultimately the premature need for pipe replacement. While more corrosion resistant types of sewer pipes are on the market (i.e., PVC), they are generally more expensive and limited in size; thus other alternatives require examination.



Concrete sewer pipe being submerged to prevent corrosion


Water droplets with bacteria oxidize hydrogen sulfide to create sulfuric acid which attacks concrete.
Gas
Sewage
Bacteria in slime converts sulfur in sewage to hydrogen sulfide gas.
Silt
CROSS-SECTION OF CONCRETE SEWER PIPE

Completed in 1979 was a long-term demonstration project which produced two promising systems for impregnating concrete pipe to improve corrosion resistance at an economically attractive cost. Each system involved impregnating pipes with chemicals—one used modified sulfur, while the other used dilute hydrofluoric acid. The pipe was impregnated by submerging it into vats containing a solution of either chemical. Early test results indicated a tenfold improvement in corrosion resistance. Impregnation of the pipe, it was found, reduced the permeability of the concrete, thus the sulfuric acid was inhibited from reacting with the interior structure of the concrete and, in the case of reinforced pipe, the steel reinforcing rods. A total of 1400 ft. of impregnated concrete pipe was installed in four Texas cities and closely monitored for corrosion. Results indicated markedly less corrosion in the treated section.

It was also established that *non*reinforced pipe impregnated with sulfur approached the strength of steel reinforced pipe. This dramatic strength improvement, coupled with the improved resistance to corrosion, points to the possibility that sulfur impregnated pipe will be used in future installations at an attractive savings in material cost. It is estimated that such savings will range from $0.83 to $2.08 per linear foot of 27-in. diameter pipe. Also, as desulfurized coal becomes a major source of energy, it is expected that sulfur as a by-product of the desulfurization process will be cheap and in good supply.

Today, it is estimated that by 1990 over 90,000 miles of new sewer pipe will be required. The cost? $17 billion. However, this figure assumes the use of conventional reinforced concrete pipe. Results to date into this ORD-sponsored research on pipe impregnation indicate a substantial taxpayer savings could well be realized in the decade to come.

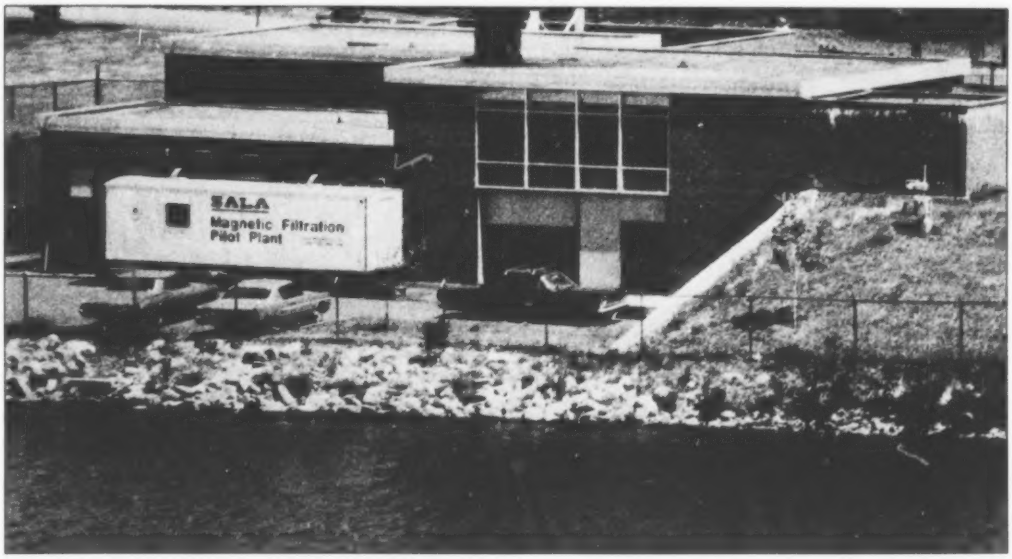
Wastewater Aerosols and Disease

In September 1979, a symposium on Wastewater Aerosols and Disease, held in Cincinnati, dealt with the results of ORD-sponsored research into microorganisms from wastewater plants. Some of the research findings presented:

- The density of airborne microorganisms from an Illinois treatment plant located 400 meters from a residential area was not distinguishable from background levels. There was no health hazard.
- Persons living within 600 meters of a Michigan sewage treatment plant had a greater than expected rate of respiratory and gastrointestinal illness, a rate that may be attributable to a high density of lower socioeconomic families, rather than plant proximity.
- A demographic and health survey of persons residing near a treatment plant in Illinois produced the overall conclusions that no obvious adverse health effects resulted from exposure to aerosol emissions, a conclusion tempered by the fact that only a small number of people were exposed to the highest pollution levels.
- Sources of microorganisms from a wastewater treatment plant in Oregon were established. No viruses were detected and attendance measures at nearby schools indicated no obvious adverse effects.
- Spray irrigation of unchlorinated wastewater was monitored in California. Pathogenic organisms were found in aerosols and were transported downwind. At 50 meters, significant densities existed, but at 200 meters, the microorganisms were virtually undetectable.
- Data were evaluated to correlate the existence of disease and the use of wastewater irrigation in kibbutzim in Israel. Preliminary results mirrored control group findings. A new study is underway.
- Sewage treatment plant workers were tested over time in three cities to determine incidences of infection and disease as a result of exposure to microorganisms. Initial results indicated slightly higher incidences of gastrointestinal illness in new workers while incidence in experienced workers did not differ from those of controls.

Overall these results combine to indicate that while a potential health problem may be created by wastewater aerosols, current state-of-the-art methodology is unable to detect a health hazard for exposed populations.

Aerated wastewater lagoon



Magnetic Separation facility

Magnetic Separation

Overflows containing both domestic waters and stormwater runoff (called combined sewer overflows) contribute substantially to the pollution of major waterways and coastal areas in the United States. Such overflow occurs most often during "first flush" storm situations, where large increases in wastes in the form of rainwater and land runoff course through sewers along with their regular load. For treatment plants to have on hand the reserve capacity to handle these surges of wastes is prohibitively costly and as a result these combined sewer overflows often enter waterways untreated.

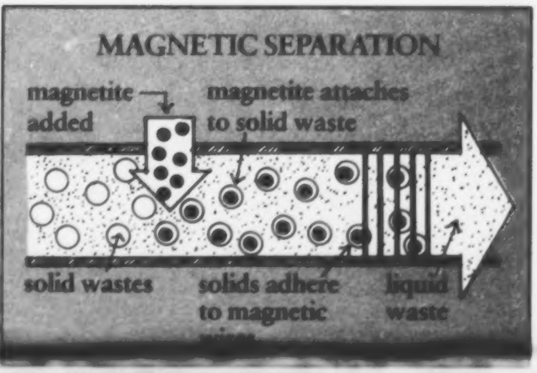
ORD research, however, has recently demonstrated the viability of a system that can handle these overloads. Called High Gradient Magnetic Separation (HGMS)® the system uses a large magnet, capable of separating suspended solids or precipitates from a large, fast-flowing volume of water. Simply, the wastewater is seeded with magnetic iron oxide (magnetite) that attaches itself to the nonmagnetic solids in the water making them weakly magnetic. As the water passes through a filter of magnetic wires, the solids adhere to the wires while the liquid passes through the filter. Any increase in wastewater volume can be accommodated either by adding more separators and/or increasing the magnetic field.

Early ORD pilot-plant work with HGMS showed the system to be capable of effectively and efficiently treating a variety of wastewater samples, demonstrating a removal efficiency of well over 90% for most parameters. In 1976, a mobile pilot plant system developed by ORD was designed to operate automatically for 24 hours, and contained two magnetic filters to simulate the operation of a full-scale variable flow capacity system such as that used at wastewater plants.

Test findings of the mobile system in 1979 bore out initial research findings. HGMS proved effective in its ability to handle dynamic situations such as those encountered in treatment installations handling both wet-weather and dry-weather flows. Storm profile tests showed that HGMS was also up to the task of handling significantly increased flow velocity without losing its effectiveness.

The system's inherent adaptability, its ability to handle large volumes of water to give treatment plants a reserve capability, and its overall size relative to conventional systems make it an attractive alternative for treatment plant use.

HGMS capital costs for an integrated wet and dry facility are estimated to be approximately 40% lower than the comparative physical-chemical systems in common use today; operations and main-



tenance costs are estimated to be about 20% lower. ORD is currently surveying potential sites for a future full-scale demonstration of HGMS treatment of combined sewer overflows.

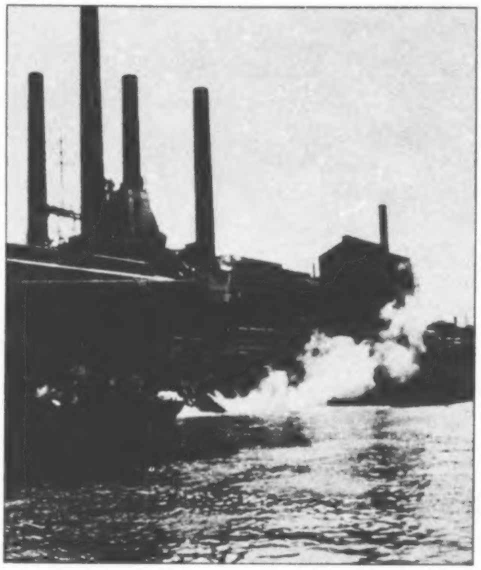
Wastewater Reuse

In a recent ORD study of 1246 municipal water supply utilities using surface water from 194 basins and serving 525 cities, wastewater from upstream sources was found in all but 142 instances. In a number of cities, in fact, wastewater was found to be a major portion of the water supply.

Such research results point clearly to the need for more effective methods in controlling wastewater discharges. While to some extent water is a renewable resource, its wholesale use in municipalities and industry subsequently creates wholesale amounts of wastewater.

EPA is supporting a number of wastewater recycle/reuse efforts and is closely monitoring independent work in this area to assure its environmental soundness. Two such programs in 1979 included demonstration of recycling methods by a paper manufacturer and the testing of an innovative wastewater reuse procedure in Orange County, California.

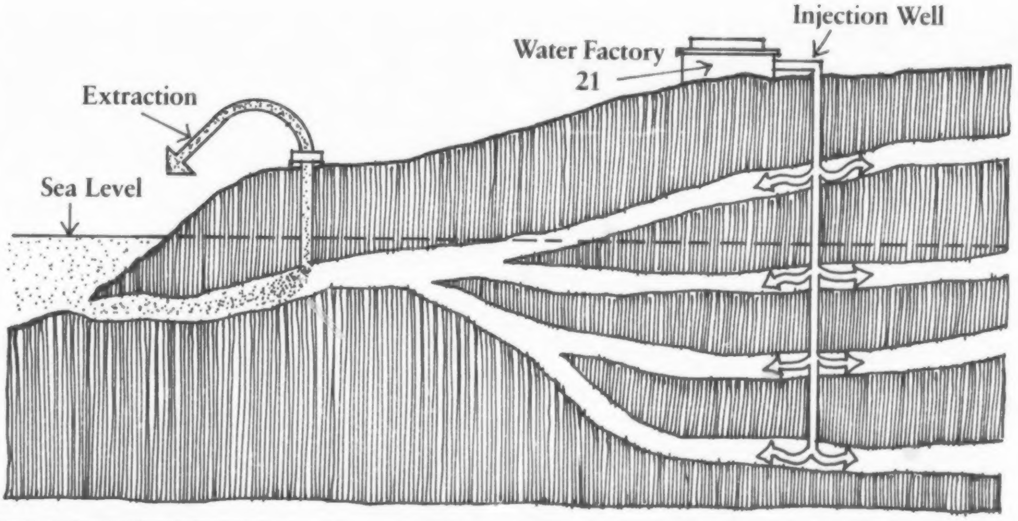
Hardboard industry water reuse program—In 1978, U.S. pulp and paper mills supplied industry with 2.4 million tons of hardboard to be used in manufacturing and construction. To accomplish this, 75% of the nation's paper mills made use of a water-intensive wet manufacturing process that resulted in the daily discharge of 18 million gallons of wastewater polluted by suspended solids and a host of toxic chemicals.



The following year, however, under an ORD-supported project, one such hardboard manufacturer utilized specialized equipment and made process modifications to recover process water and chemicals from the mill's waste stream. As a result, the volume of wastewater discharged from the mill was reduced by more than 97%, and the decrease in pollution load was approximately 87%.

Although there were some production problems encountered early in the study period, solutions were found and product quality and production rates equalled or exceeded premodification levels. Freshwater requirements were drastically lowered and the use of chemicals, both for hardboard processing and wastewater treatment, was reduced.

SEAWATER BARRIER AT WATER FACTORY 21



Groundwater recharge — ORD research has also been integrated into the construction and operation of the Orange County Water District's Water Factory 21 located in Fountain Valley, California, one of the nation's most innovative water treatment technology and municipal wastewater reuse facilities. Here, treated wastewater is injected into the ground through wells, where it performs two vital functions. First, the wastewater provides a barrier that prevents the incursion of sea water into heavily mined groundwater aquifers. Second, this highly treated wastewater actually recharges the depleted Orange County groundwater basin. Such recharged groundwater, it is thought, might well be capable of creating the supplemental water that may be necessary in water-short areas in the coming century.

Over the last three years, Water Factory 21 has been demonstrating the feasibility of renovating municipal wastewater for groundwater recharge. Some 15 million gallons per day of reclaimed municipal secondary effluent have been injected into the groundwater basin through a series of 23 injection wells. Wells are spaced approximately 600 feet apart and span the Talbert Gap, the historic flood plain of the Santa Ana River, an area subject to sea water intrusion.

The wastewater used in the injection system has undergone the most comprehensive treatment to assure that existing aquifers are not threatened — lime treatment to remove suspended solids and heavy metals, ammonia stripping and initial chlorination to remove nitrogen, filtration and activated-carbon adsorption to remove organics and additional suspended solids, reverse osmosis for demineralization, and final chlorination for disinfection. In a recent ORD continuous operation and monitoring program, it was demonstrated that Water Factory 21 produced a product on a par with and often better than drinking water sources used by many municipalities today. It was further demonstrated that the treatment plant was reliable in the removal of trace contaminants. During the program, sufficient data were generated to evaluate the effectiveness of the plant's various treatment technologies—individually and in combination — in removing those materials of concern to public health.

Overall, findings indicate that the combined wastewater treatment processes employed at Water Factory 21 are certainly capable of producing water that is suitable for injection as a seawater barrier and that quite probably offer the additional promise of removing a public health concern associated with mixing wastewater with groundwater in an aquifer used for general municipal purposes.

The following ORD components contributed to the research described above:

- ■ Office of Environmental Engineering and Technology—Municipal Environmental Research Laboratories, Edison and Cincinnati, and Industrial Environmental Research Laboratory, Cincinnati
- ■ Office of Health Research—Health Effects Research Laboratory, Cincinnati

INFORMATION TRANSFER

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ORD continues to insure public access to its scientific information

EPA derives significant benefit from the mass of information generated by ORD programs in a given year. For the greatest benefits to be realized, however, this information must also be made available and accessible to the public as well as to other federal agencies and to state and local governments. The means for accomplishing this at ORD include films, publications, videotapes, and data recovery systems. The following is a selection of ORD's 1979 information transfer highlights.

Film—"Hold This Land"

Hold This Land is an ORD-sponsored 23-minute color film narrated by Robert Redford that deals with the water pollution problems that can be brought about by farmland irrigation, and the benefits that can be expected if various control measures and management practices are implemented.

This film focuses on the good works of one progressive farmer, and shows how he converted soil sediments eroded from his land during irrigation into topsoil for use on 60 acres of formerly barren, rim-rock land. By collecting the sediment from his and his neighbors fields in settling basins, then spreading the soil where it was needed, productive cropland was created and the value of his land increased.

The film also focuses on a number of other cases where new and innovative technologies have been demonstrated effective in controlling the soil erosion and sedimentation that results from irrigation. These technologies include improved water distribution and application systems as well as drainage systems designed to keep the sediment on the fields instead of allowing it to accumulate in streams and river basins.

The idea for the film was born in 1975 when an independent Idaho filmmaker saw a draft copy of a state-of-the-art report on "Control of Sediment, Nutrient and Absorbed Biocides in Surface Irrigation Return Flows," being prepared for ORD. Interested and inspired by its findings, the filmmaker, with funding by ORD and consultation by the Agricultural Research Staff of the Department of Agriculture's Science and Education Administration, produced a film that translates the technical concepts presented in the report into visual ones. Most of the footage was shot in Twin Falls, Idaho, though to broaden the film's scope some sequences take place in California and Washington.

The film has been widely used by farmers, cooperative extension personnel, local and state action agencies as well as control agencies. The film has also been well received by universities as a teaching aid in environmental awareness education. Copies of the film are available at each of EPA's Regional Offices for loan to local school officials and other interested groups or individuals.

Videotape-Asbestos

Airborne asbestos fibers inhaled into the lungs are a cause of lung cancer, asbestosis, and mesothelioma. The period between exposure and the actual lung disease can range from 15 to 40 years. While the degree of exposure that can bring about such dysfunction has not been established, evidence points to the fact that even small amounts of asbestos fibers can prove to be exceedingly harmful.

When it was discovered that asbestos, used in school buildings as fireproofing, was deteriorating, releasing large amounts of fibers into the buildings' air space, the EPA Office of Pesticides and Toxic Substances immediately initiated a corrective action program which included publication of a comprehensive guidance document entitled *Asbestos-Containing Material in School Buildings*. In support of this document and the overall effort, in 1979, ORD also produced a videotape entitled *What Your School Can Do About Friable Asbestos-Containing Materials*.

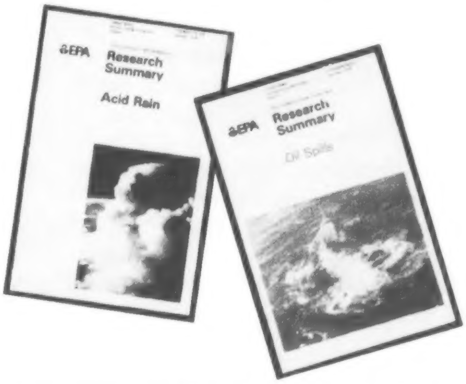
Much of the information contained in the videotape was an outgrowth of ORD's ongoing study of commercially available treatments that can be sprayed on asbestos to lock or seal fibers into place. Beyond the information, the tape communicates the seriousness of the problem and the fact that EPA is prepared to aid school officials in evaluating asbestos hazards in their buildings and deciding on means for correction.

The videotape was used in the press conference announcing the corrective actions effort and is currently available for loan at all of the EPA Regional Offices.

Farmland irrigation scene from film "Hold This Land"

Publications

Research Summary Series. In 1979, the Research Summary Series was initiated to provide concise non-technical information concerning the major areas of ORD research to a wide audience. Each summary brochure begins with a brief discussion of an environmental problem area and outlines ORD approaches for its solution. The brochure's main body contains descriptions of major ORD research projects, past and present. Title listings for current research being performed at or through EPA laboratories or offices and a listing of sources for additional information comprise the remainder of the publication.



Two summaries have been completed to date: *Oil Spills,* and *Acid Rain,* the latter having been submitted to the National Commission on Air Quality as part of EPA's testimony on the environmental consequences of acid precipitation in the United States.

Summaries in preparation deal with topics such as the control of nitrogen oxide and sulfur oxide emissions, industrial wastewater treatment, integrated pest management, sewage sludge disposal and hazardous wastes control.

Environmental Assessment Series. A second new ORD report series, the Environmental Assessment Series, will focus on issues involving toxic substances and their effects on human health. This series is a natural outgrowth of EPA's efforts and resources currently directed at regulating the release of toxic chemicals into the environment, and is intended for the reader whose chief concern is the protection of human health.

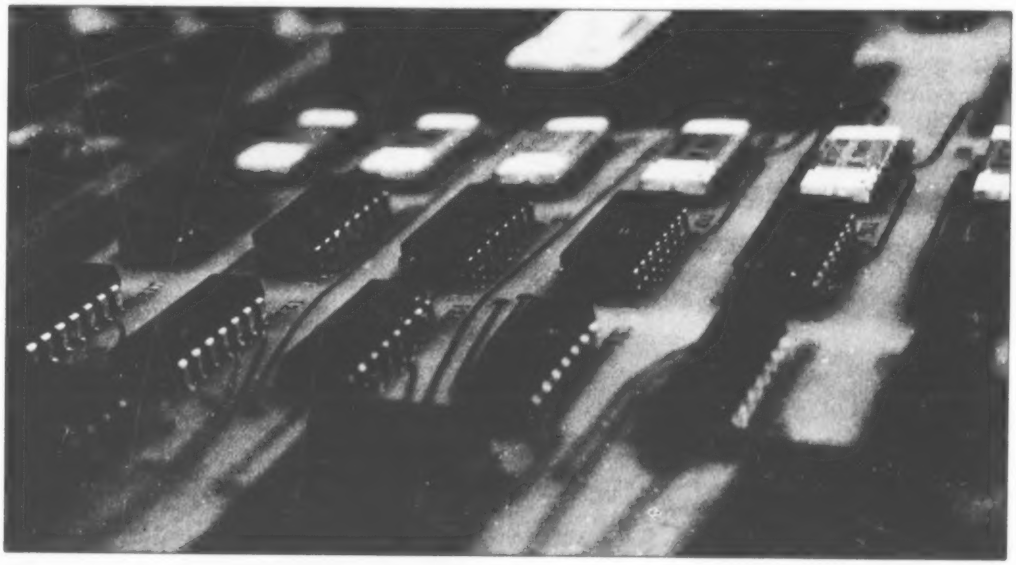
The first report in the series, *Short-Term Tests for Carcinogens, Mutagens and Other Genotoxic Agents,* was published in 1979 and addresses the use of short-term tests to predict a chemical's potential long-term effects on human genetic material. The problem that had perplexed researchers for years was how to quickly and accurately determine whether a substance was safe for human use or whether it caused delayed deleterious effects. The research documented in this report constitutes a significant step forward in the area of short-term testing. The report discusses the advantages and disadvantages of these testing techniques, and the way they can contribute to toxic material effects assessments. The scientific basis for these tests as well as current applications and research activities are also discussed.

Environmental Outlook is a report prepared annually by ORD's Strategic Analysis Group. It is EPA's look into the future of our air, water, and land as well as its look at the future of the specific pollutants that impact on them. Traditionally, this publication was limited to reporting data generated by a large computerized environmental assessment system about quantitative trends for selected pollutants.

Environmental Outlook 1980, however, represents a major step toward making this annual report a more provocative and comprehensive look into the environmental future. The number of pollutants dealt with was expanded, and their environmental implications discussed. Trends from other sources were reported and information on public attitudes and environmental legislation and regulation was included.

Among the report's highlights were two scenarios representing contrasting environmental views of the closing years of the twentieth century. Each scenario makes use of different assumptions

EPA Environmental Assessment
Short-Term Tests for Carcinogens, Mutagens and Other Genotoxic Agents



Sophisticated data processing has become essential to utilize the wide range of ORD research projects

about economic growth, trends in employment, population growth and distribution, energy supply and demand, and environmental standards and policies. The purpose of these two scenarios was not so much to present two views of the future as it was to present two sets of boundaries from which reasonable forecasts and analyses of that future could be made.

An important set of findings contained in *Environmental Outlook 1980* are those pertaining to public attitudes toward the environmental future. According to an EPA survey, the public continues to show a consistent concern for environmental quality, including a general reluctance to relax environmental standards to achieve economic growth. This interest is also present in the legislation and executive branches of government where enhancement and protection of public health and the environment has been demonstrated to be on the increase.

Project Tracking System

The well-known and often evoked "information explosion" of the mid-twentieth century has not passed EPA by. With literally thousands of individual research projects under way at any one time, the amount of information being generated is extensive, if not overwhelming.

The Project Tracking System is a computerized data bank that contains key information on all of ORDs individual research projects. The data contained in the bank include descriptions of the work being performed, research results of the previous quarter, the names of the principal investigators involved and a host of other project administrative and management information.

The data bank is maintained at EPA's Washington Computer Center where it is accessible by way of a variety of search methods, the most widely used of which is a keyword search process. Over 6,000 keywords are listed, from the general ("ecosystem," "carcinogenisis") to the specific ("enzyme interaction," "immunohistology"). Recent system improvements allow for a variety of sophisticated search procedures. Today, for example, to retrieve information on projects related to the health effects of coal-fired boilers, the key words "coal," "health effects," and "boilers," may be entered simultaneously and the system will print out only those projects having those three keywords in common.

The data bank is also programmed to produce information that falls into broader categories, and searches are possible for data that link one such category to another. For example, if one wanted information on all research mandated by the Marine Protection Research and Sanctuaries Act and done in support of the Office of Water and Waste Management, a search code for the legislation and a search code for the program office is entered and all projects having the two given codes in common would then be retrieved.

The following ORD components contributed to the research described above:

- Office of Environmental Processes and Effects Research, Kerr Environmental Research Laboratory, Ada
- Office of Environmental Engineering and Technology, Industrial Environmental Research Laboratories, Cincinnati
- Office of Research Program Management, Technical Information Office, Center For Environmental Research Information, Cincinnati

ORD PROGRAM EXPANDS

New Multipurpose Test and Evaluation Facility at the Mill Creek Sewage Plant in Cincinnati

ORD expands in an effort to better anticipate future environmental research needs

To remain current in the ever-expanding research and informational world requires anticipating tomorrow's needs today. Thus, when the future does arrive, the groundwork will have already been laid to interpret new information as it develops. For EPA to fulfill its mission, ORD must continuously look to that future—to assure that the proper tools and facilities exist, to plan research directions, to assure that grants, contracts, and cooperative agreements are awarded to the most qualified researchers, and to guarantee the existence of a well-trained workforce capable of meeting future environmental challenges. In 1979, the ORD program expanded to better meet these future needs.

EPA and the Academic Community

The concept of "Institutional Centers of Excellence" was born out of the 1978 decision to commit part of ORD's annual research budget to long-term exploratory research in a number of key areas. This research will be performed by ORD in cooperative agreement with those organizations and institutions—the centers of excellence—having well-established credentials in the key research areas and a demonstrated commitment to such research.

The focus of each center program will generally be long-term exploratory research (3 to 5 years or more). It is expected that ORD will be taking an active role during the span of this work, for unlike grants and contracts, such cooperative agreements require the sponsoring agency's substantial involvement in all facets of the program on a continuing basis. Consequently, it is expected that the results of this joint ORD/institution effort will be a synthesis between the basic work most often carried out by universities and the applied research ORD requires to assist EPA in carrying out its mission. Beyond this, the center programs are designed to:

- Serve as a resource for ORD laboratories within a broad research area in which a national need has been identified.
- Fill research gaps and address areas requiring expansion.
- Stimulate ORD's applied research programs.
- Serve as a talent pool for prospective scientists in the environmental field.

ORD must continuously look to the future

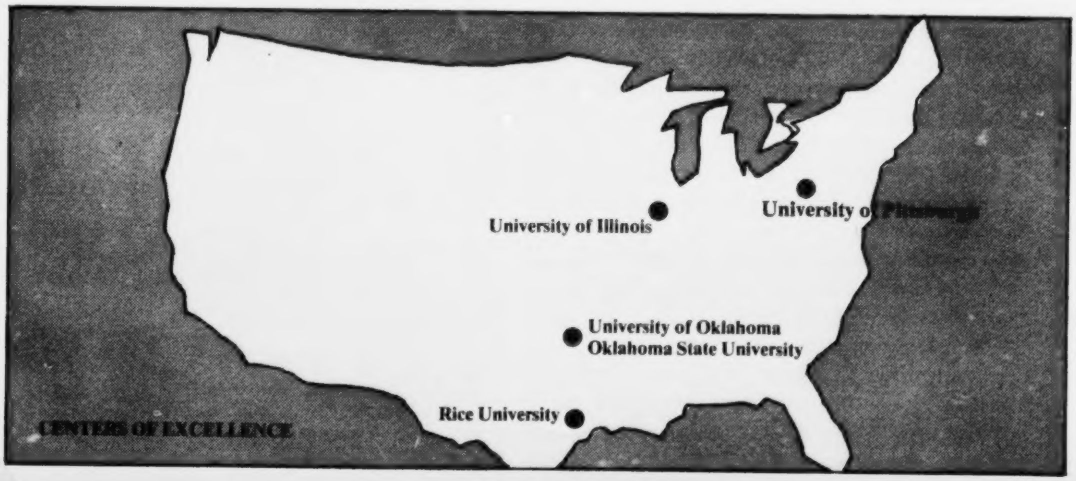
The major 1979 highlights of the fledgling "centers" program was the selection of the initial four areas for exploratory research and the subsequent selection of centers that would perform the research. An August announcement named the University of Pittsburgh as the Epidemiology Research Center, a consortium of the University of Oklahoma, Oklahoma State University, and Rice University as the Groundwater Center, and the University of Illinois as the Advanced Control Technology Center. In December the Marine Environmental Sciences Research Center was selected. It is located at the University of Rhode Island's Graduate School of Oceanography and is augmented by scientists from the Woods Hole Oceanographic Institute, the University of Maryland, Bryant College and Columbia University.

Studies at the Epidemiological Center will focus on the human health risks associated with environmental pollution. Research will include studies into the population distribution of health effects, the development of improved research methodologies, the conduct of prospective epidemiological studies, and the improvement of statistical techniques.

Three major research areas will be addressed at the Groundwater Center. Subsurface characterization research will be primarily involved with the study of soils and how they control the movement and transformation of chemicals. Transport and fate studies will concentrate on the development and application of laboratory tests and systems to evaluate the behavior of chemicals in the soil. Methods development research will center around the evaluation and development of drilling and coring field tests used to collect subsurface samples.

Some examples of the research to be carried out at the Advanced Control Technology Center are:

- Investigation of microbiological metabolic processes.
- Evaluation of combustion phenomena.
- Studies of the basic mechanisms of physical and chemical separator processes.
- Evaluation of the innovations in reprocessing and recycling.



Two key research subjects to be addressed by the Marine Environmental Sciences Research center are:

- Determination of effective means to assess the state of health of marine ecosystems under stress.
- Study of pathways and processes influencing exposure of man or marine ecosystems to toxic substances.

Four additional centers are planned for 1980

Three additional centers are planned with EPA's Anticipatory Research Program for 1980. Research will focus on:

- Solution of waste disposal problems.
- Intermedia transport—the study of the interaction between air pollutants and the earth's surface.
- Integrated ecosystem studies—the investigation of stressed ecosystems.

New Grant Procedure

During 1979, ORD took steps to revamp its system of grant proposal solicitation, review, and project management. As a result of the findings of the specially convened Grant's Procedure Review Group, ORD administrative regulations were updated and revised to provide a more open and competitive system encouraging a wider range of input and a higher quality final research project.

In response to the Review Group's recommendation to broaden the base of research applications considered, proposal solicitations are now being developed that better reflect the research needs identified both by ORD laboratory directors and by each ORD Research Committee. To encourage the widest response, solicitations will appear as "flyers" and in other media such as technical journals, and trade publications.

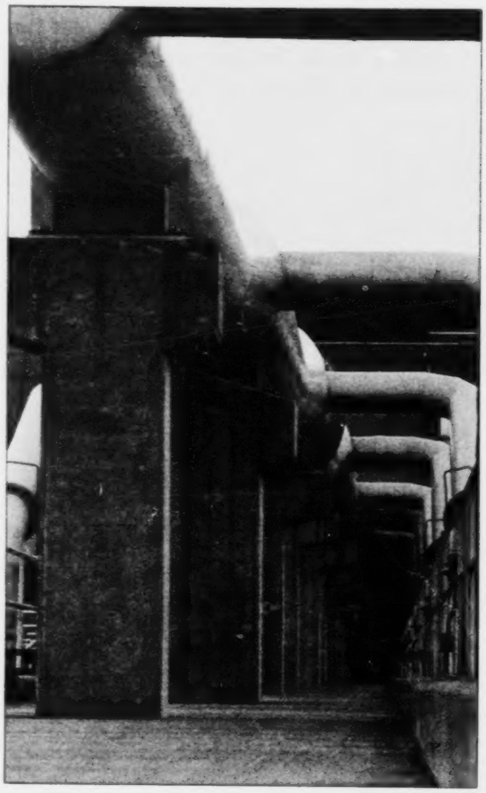
A new peer panel review process also recommended by the Review Group, will be in operation by February, 1980. All grant and cooperative agreement applications will be reviewed by peer panels, whose members are selected for their scientific expertise. The panels, made up in part by ORD laboratory scientists, will evaluate the scientific merit of each proposal, with final funding decisions contingent on the applicability of the proposal to ORD's research needs, priorities, and the availability of funds.

It is expected that the nature of this system will improve the quality of EPA's research output, increase operational efficiency and effectiveness, and enable ORD laboratory scientists to devote more time to EPA cooperative agreements and less time to the management of grants.

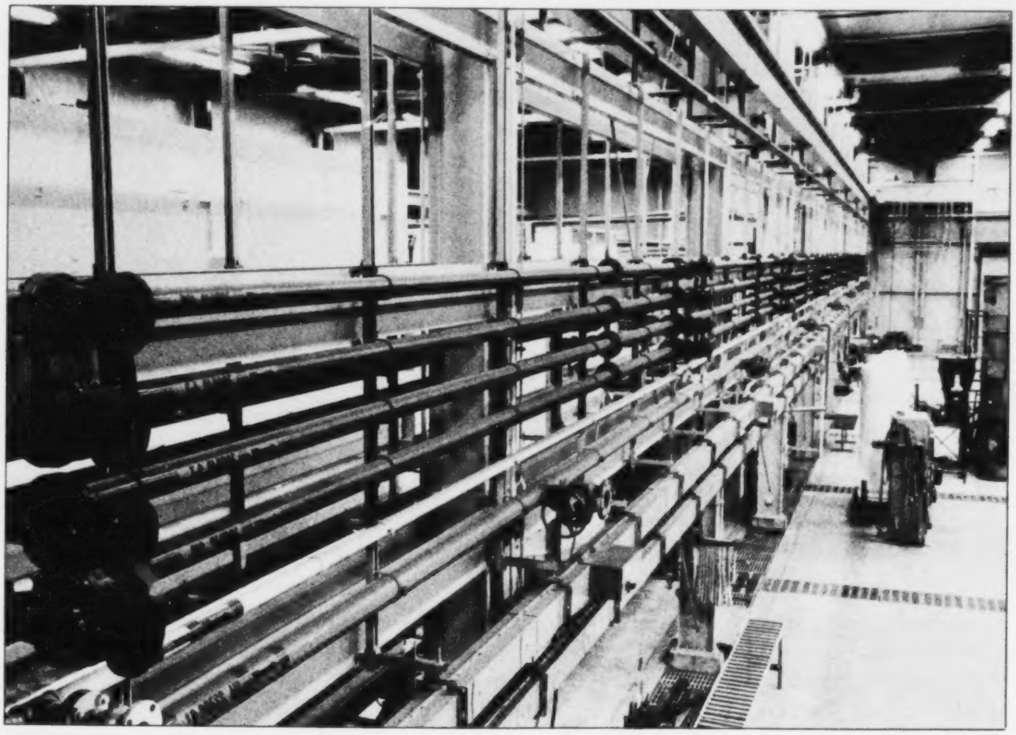
Testing and Evaluation

Traditionally, the assessment of municipal and industrial waste and wastewater control technologies, the development of test instruments and monitoring methods, and the evaluation of effluents for toxicity were all functions conducted by different ORD laboratories at a variety of locations. To streamline such research EPA recently constructed a $2.6 million Multipurpose Test and Evaluation (T&E) Facility at the Mill Creek Sewage Plant in Cincinnati. Here the five EPA Cincinnati laboratories are now able to perform broad-based cooperative studies under a single roof.

Under this roof, for example, the effluents generated in pilot-plant studies of municipal waste control technologies can be used for toxicity tests, while elsewhere in the two-story 33,500 square foot facility, instruments and monitoring methods might be undergoing simultaneous testing on a wide variety of wastewaters and contaminated atmospheres.



Piping system at the Mill Creek Testing and Evaluation Facility



Interior of the Mill Creek Testing and Evaluation Facility

Beyond the facility's value for integrated research, is its flexible design, which will allow it to function optimally today and also extends its ability to function well into the future. All of the municipal sewage and sludges generated at the Mill Creek Plant, for example, can be made available via a piping system to any of 16 stations around the ORD facility thus the use of space is optimized and the efficiency of research enhanced. A wide variety of industrial effluents are also "on tap".

The ORD plant includes all the facilities and services required to conduct bench and pilot-scale research on water pollution, air pollution, and solid and hazardous waste technology, and will be ideal for the testing of advanced treatment concepts.

Projects currently underway at the new facility include:

- An evaluation of the fate of priority pollutants once they enter sewer systems and publicly owned treatment works.
- An evaluation of the relative efficiency of five generic types of ozone contactors for use in disinfection of treatment plant effluents.
- An evaluation of municipal and industrial sludge dewatering.
- An investigation into the viability of disinfecting industrial wastes containing toxic compounds by subjecting them to high temperatures.
- An analysis of the effects of landfill leachates on conventional sewage treatment.

Neurotoxicology

Certain chemicals attack the nervous system, producing disabling behavioral or neurological disorders. These chemicals originate from a variety of sources and can enter the body by a variety of routes. While ORD is not unfamiliar with many of these toxics and their effects, much of what has been learned came as a result of some environmental mishap rather than systematic research. We have gathered a fair amount of neurotoxicological data, for example, as a result of the 1975 kepone discharge into the James River, and the 1977 Michigan food contamination case, which stemmed from the inadvertant mixing of PBB (polybrominated biphenyls used in flame retardants) in cattle feed.

In 1979, to provide a framework for the more systematic, less reactive study of the effects of toxic agents on the nervous system, EPA and the Food and Drug Administration established the National Program in Neurotoxicology. Based at a major research facility, work is already under way investigating the behavioral, neurophysiological, biochemical, and pathological consequences of exposures to toxicants.

Current staffing is expected to increase by approximately one-third in the next calendar year and a National Search Committee has been formed to aid in the selection of a permanent program director.

The objective of the program is to provide a

coordinated research effort to minimize regulatory agency research overlaps and, with its full-scale multidisciplinary program, to be able to respond quickly to a variety of agency needs.

In the long term, it is expected that the program will: improve testing methods through development of cost-effective, efficient, and sensitive test systems; evolve a clearer understanding of how toxics produce adverse effects on the nervous system; and establish a data base which can be used by regulatory agencies to develop standards to protect human health.

Outreach—The Environmental Workforce Program

Most of the 800,000 workers in environmental fields are not federally employed. Widely dispersed in the economy, many workers are in emerging occupations for which no training is available. ORD's workforce program seeks to connect these workers to the nation's education and employment resources to develop a skilled environmental workforce capable of meeting present and future needs.

1979 saw national recognition of the Senior Environmental Employment Program (SEE). This EPA/Administration On Aging interagency program provided funds to ten states across the country to hire an average of 22 senior citizens to perform a variety of environmental jobs. Among the tasks undertaken were dump inspection and closure, drafting, pesticide inventory, treatment plant trouble-shooting, feed lot and grain elevator inspections, surveys of nonpublic drinking water supplies, and pesticides protection training. The program was deemed successful by EPA, Congress, states, independent evaluators, and the SEE workers and supervisors. Recently, legislative provisions were made for its expansion at the national level.

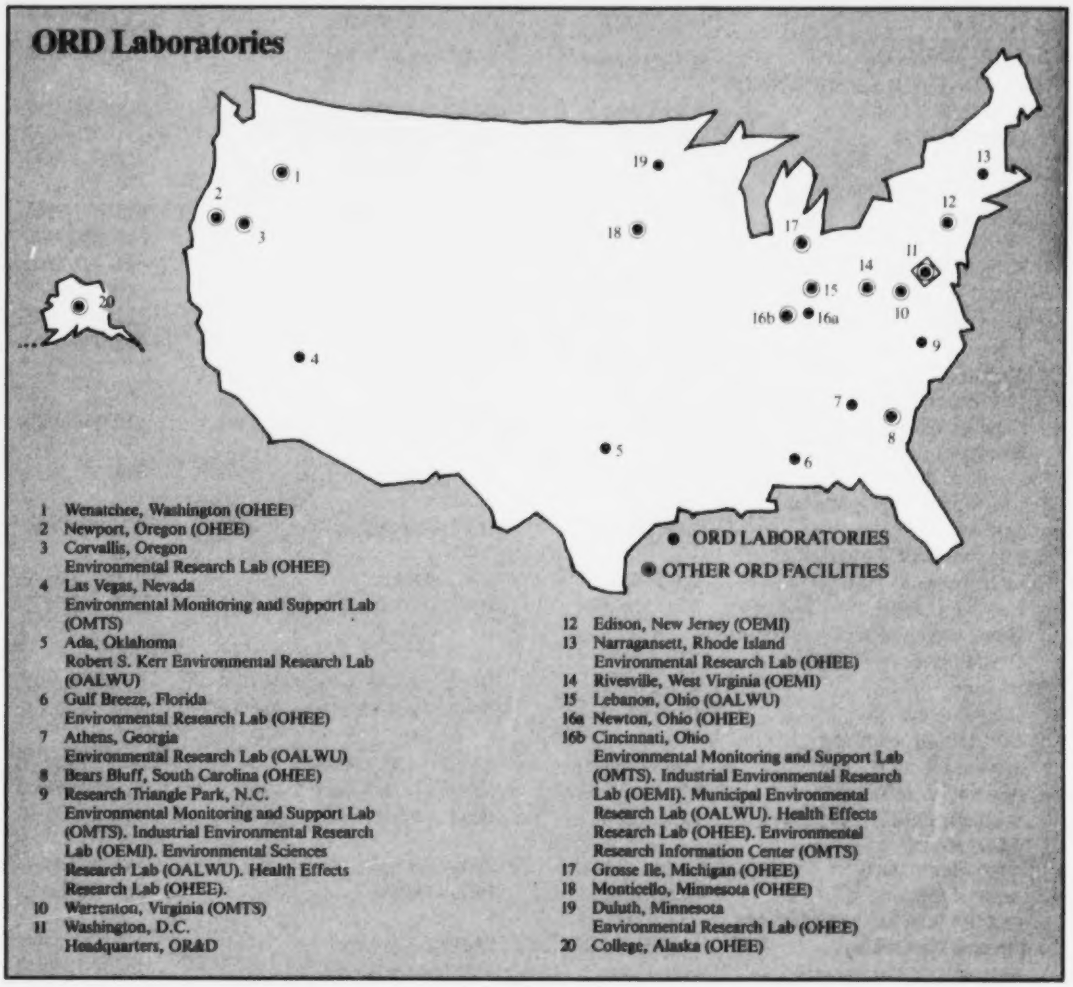
A related 1979 highlight was the development of a comprehensive strategy to upgrade the environmental workforce by interfacing with the cooperative education programs offered by many of the nation's colleges and universities. As a first step in implementing this strategy nationally, a project was initiated that will afford Colorado State University engineering and science students enrolled in cooperative education and work/study programs the opportunity to participate in career-ladder jobs in state and local environmental agencies.

In 1979, ORD also continued its coordination and reporting of EPA's successful direct training programs. In all, 111 short courses were offered, 87 air pollution courses, 19 wastewater courses, and 5 drinking water courses. Over 2800 students received a total of 12,609 student-days of instruction. Of these, 21% were federal employees, 39% were state employees, and 16% were local employees. The remaining 24% consisted of consultants, professors, industrial participants, and other interested students.

The following ORD components contributed to the research described above:

- Office of Anticipatory Research
- Office of Monitoring and Technical Support—National Workforce Development Staff
- Office of Monitoring and Technical Support—Municipal Environmental Research Laboratory, Cincinnati

ORD RESOURCES



ORD Laboratories

1 Wenatchee, Washington (OHEE)
2 Newport, Oregon (OHEE)
3 Corvallis, Oregon
Environmental Research Lab (OHEE)
4 Las Vegas, Nevada
Environmental Monitoring and Support Lab (OMTS)
5 Ada, Oklahoma
Robert S. Kerr Environmental Research Lab (OALWU)
6 Gulf Breeze, Florida
Environmental Research Lab (OHEE)
7 Athens, Georgia
Environmental Research Lab (OALWU)
8 Bears Bluff, South Carolina (OHEE)
9 Research Triangle Park, N.C.
Environmental Monitoring and Support Lab (OMTS). Industrial Environmental Research Lab (OEMI). Environmental Sciences Research Lab (OALWU). Health Effects Research Lab (OHEE).
10 Warrenton, Virginia (OMTS)
11 Washington, D.C.
Headquarters, OR&D
12 Edison, New Jersey (OEMI)
13 Narragansett, Rhode Island
Environmental Research Lab (OHEE)
14 Rivesville, West Virginia (OEMI)
15 Lebanon, Ohio (OALWU)
16a Newton, Ohio (OHEE)
16b Cincinnati, Ohio
Environmental Monitoring and Support Lab (OMTS). Industrial Environmental Research Lab (OEMI). Municipal Environmental Research Lab (OALWU). Health Effects Research Lab (OHEE). Environmental Research Information Center (OMTS)
17 Grosse Ile, Michigan (OHEE)
18 Monticello, Minnesota (OHEE)
19 Duluth, Minnesota
Environmental Research Lab (OHEE)
20 College, Alaska (OHEE)

Funding for Fiscal 79—
303.9 million, 1844 people

ORD Funding by Media	**$M**
Air	50.8
Water Quality	66.2
Drinking Water	17.6
Pesticides	12.5
Radiation	1.9
Toxics	10.1
Energy	112.1
Solid Waste	7.5
Interdisciplinary	17.7
Management and Support	7.5
Total	**303.9**

ORD Funding by Categories	**$M**
Health Effects	65.9
Ecology	34.3
Transport and Fate	27.3
Monitoring	38.1
Control Technology	121.6
Other	16.7
Total	**303.9**

ORD Funding by Mechanism		
Contracts	$88.8M	29%
Grants	$71.0M	23%
IAGs	$49.6M	16%
In-house	$94.5M	32%

THE PEOPLE

SUBJECT	CONTACT	ORGANIZATION	TELEPHONE
THREE-MILE ISLAND	Eric Bretthauer	EMSL—Las Vegas	702/736-2969
EMERGENCIES/ASSISTANCE			
PCB Spills	R. G. Lewis	HERL—Research Triangle Park	919/541-2510
Clean Up	Ira Wilder	IERL—Edison, N.J.	201/321-6635
Sprayed-On Asbestos	William Cain	IERL—Cincinnati	513/684-4334
Benzene Contamination of Water	Robert Miday	HERL—Cincinnati	513/684-7461
Neskowin, Oregon	Walter Grube	HERL—Cincinnati	513/684-7406
Land Treatment	Richard Duty	RSKERL—Ada, Okla.	405/332-8800
Aerial Imagery	Clayton Lake	EMSL—Las Vegas	702/736-2969
Secondary Lead Standards	Fred Craig	IERL—Cincinnati	513/684-4491
Peru	Victor Lambou	EMSL—Las Vegas	702/736-2969
ENERGY			
Conversion from Scarce Oil to Plentiful Coal	Wade Ponder	IERL—Research Triangle Park	919/541-2915
Enhanced Pollution Control —Adipic Acid	Michael Maxwell	IERL—Research Triangle Park	919/541-2578
Limestone Coal Pellets for Sulfur Control	Jack Wasser	IERL—Research Triangle Park	919/541-2476
Environmental Impact of Coal-Fired Power Plant Sites	Gary Glass	ERL—Duluth	218/727-6692
Low NO_xBurner Field Testing	Blair Martin	IERL—Research Triangle Park	919/541-2235
Home and Service Guides for Gas Furnaces and Water Heaters	Robert Hall	IERL—Research Triangle Park	919/541-2477
Coal Gasification	Dean Smith	IERL—Research Triangle Park	919/541-2235
Oil Shale Groundwater Monitoring	Les McMillian	EMSL—Las Vegas	702/736-2969
Alcohol From Wastes	Charles Rogers	MERL—Cincinnati	513/684-7881
Synthetic Fuel Symposium	Dean Smith	IERL—Research Triangle Park	919/541-2708
ACID RAIN			
Terrestrial Impacts	Charles Powers	ERL—Corvallis, Ore.	503/757-4671
Aquatic Impacts	Gary Glass	ERL—Duluth	218/727-6692
CLEAN AIR MONITORING			
Optimal Air Quality	Jim McElroy	EMSL—Las Vegas	702/736-2969
Atmospheric Particulates	John Eckert	EMSL—Las Vegas	702/736-2969
What is Visibility	William Malm	EMSL—Las Vegas	702/736-2969
Satellites and Solar Cells	Jeff Van Ee	EMSL—Las Vegas	702/736-2969
Remote Optical Sensing	William Herget	ESRL—Research Triangle Park	919/541-3184
Atmospheric Sulfates Analysis	Jim Homolya	ESRL—Research Triangle Park	919/541-3085
Fugitive Emissions	Bruce Tichenor	IERL—Research Triangle Park	919/541-2821
NON-IONIZING RADIATION	Ralph Smialowicz	HERL—Research Triangle Park	919/541-2541
TOXICS			
Great Lakes	Gilman Veith	ERL—Duluth	218/727-6692
Complex Effluents	William Horning	HERL—Newtown, Ohio	513/684-8601
Short-Term Tests	Michael Waters	HERL—Research Triangle Park	919/541-2281
Molecular Indicators	G. M. Christianson	ERL—Duluth	218/727-6692
Dioxin in Sludge	David Watkins	IERL—Cincinnati	513/684-4402
Airborne Asbestos	Jack Wagman	ESRL—Research Triangle Park	919/541-2191
Hemoglobin as a Dose Monitor	Michael Pereira	HERL—Cincinnati	513/684-7401
Aquatic Animals as Indicators	J. A. Couch	ERL—Gulf Breeze, Fla.	904/932-5311
Test Protocols	James Falco	ERL—Athens, Ga.	404/546-3134
Heavy Metals' Effects on Fish	Ron Garton	ERL—Corvallis, Ore.	503-757-4601
Validation of Short-Term Screening Tests	Ron Garton	ERL—Corvallis, Ore.	503/757-4601
Pulmonary Functions in Small Animals	John O'Neil	HERL—Research Triangle Park	919/541-2281
Behavioral Teratology	Earl Gray	HERL—Research Triangle Park	919/541-2281
Post Natal Mouse	Neil Chernoff	HERL—Research Triangle Park	919/541-2281

SUBJECT	CONTACT	ORGANIZATION	TELEPHONE
ANALYTIC TECHNIQUES			
Toxic Compound Analysis	Dwight Ballinger	EMSL—Cincinnati	513/684-7301
Ozone Calibration	Tom Hauser	EMSL—Research Triangle Park	919/541-2106
Primary Sulfate Emissions	Jim Homolya	ESRL—Research Triangle Park	919/541-3085
Aerosol Acidity Analysis	Robert Stevens	ESRL—Research Triangle Park	919/541-3156
Undetected Pollutants Now Measurable	Charles Anderson	ERL—Athens, Ga.	404/546-3183
RESOURCE CONSERVATION AND RECOVERY ACT			
Safety and Hazard Guide	Victor Lambou	EMSL—Las Vegas	702/736-2969
Soils Grouting	Ira Wilder	IERL—Edison, N.J.	201/321-6635
Mobile Carbon Regenerator	Ira Wilder	IERL—Edison, N.J.	201/321-6635
Classification Methods	R. L. Stenburg	MERL—Cincinnati	513/684-7861
Wastes as Fuel	George Huffman	IERL—Cincinnati	513/684-4478
Scrap Futures	Oscar Albrecht	MERL—Cincinnati	513/684-7881
Deep Well Injection	Jack Keely	RSKERL—Ada, Okla.	405/332-8800
Movement of Organics in Groundwater	Marion Scalf	RSKERL—Ada, Okla.	405/332-8800
Indicatory Fate Study	Leon Myers	RSKERL—Ada, Okla.	405/332-8800
WATER QUALITY			
Trout, Salmon, and Nutrients	Jack Gakstatter	ERL—Corvallis, Ore.	503/757-4611
Laser Fluorsensor	Mike Bristow	EMSL—Las Vegas	702/736-2969
Forestry Management	Lee Mulkey	ERL—Athens, Ga.	404/546-3581
Lake Restoration	Spence Peterson	ERL—Corvallis, Ore.	503/757-4794
COASTAL ENVIRONMENT			
Wetlands	Hal Kibby	ERL—Corvallis, Ore.	503/757-4713
Ocean Outfalls	Don Baumgartner	ERL—Corvallis, Ore.	503/757-4722
Offshore Drilling	Norman Richards	ERL—Gulf Breeze, Fla.	904/932-5311
CHESAPEAKE BAY	Tom DeMoss	Annapolis, Md.	301/266-0077
MUNICIPAL WASTEWATER			
Treatment Plant Operation and Design	Francis Evans III	MERL—Cincinnati	513/684-7610
Ultraviolet Light	Al Venosa	MERL—Cincinnati	513/684-7668
Concrete Pipe	Richard Field	ERL—Edison, N.J.	201/321-6674
Wastewater Aerosols and Disease	Herb Pahren	HERL—Cincinnati	513/684-7217
Magnetic Separation	Richard Field	MERL—Edison, N.J.	201/321-6674
Hardboard Water Reuse	Michael Strutz	IERL—Cincinnati	513/684-4227
Groundwater Recharge	John English	MERL—Cincinnati	513/684-7613
INFORMATION TRANSFER			
Film—Hold This Land	Arthur Hornsby	RSKERL—Ada, Okla.	405/332-8800
Videotape—Asbestos	William Cain	IERL—Cincinnati	513/684-4334
Research Summary Series	Mark Schaefer	Technical Information Office, Washington, D.C.	202/426-9454
Environmental Assessment Series	Clarence Clemons	CERI—Cincinnati	513/684-7394
Project Tracking System	Albert Pines	Technical Information Office, Washington, D.C.	202/426-9454
ORD PROGRAM EXPANDS			
EPA and the Academic Community	Edward Schuck	Anticipatory Research Program, Washington, D.C.	202/755-0655
Testing and Evaluation	Irwin Kugelman	MERL—Cincinnati	513/684-7633
Neurotoxicology	Lawrence Reiter	HERL—Research Triangle Park	919/541-2671
Outreach: Environmental Work Force	Don Cook	National Workforce Development Staff— Washington, D.C.	202/755-2937 202/755-2937

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